THE IMPACT OF COVID-19 PANDEMIC ON TRAFFIC GENERATION AND PARKING DEMAND AT HOSPITALS

by

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DECLARATION

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ABSTRACT

This study investigates the impact of COVID-19 pandemic on the traffic generation and parking demand on hospitals. Coronavirus disease first started in Wuhan, China and was reported as the global pandemic by World Health Organization (WHO) in December 2019. The virus was found to be highly contagious and could be transmitted very easily from person to person such as by spending time with an infected person. The global village opted to closing borders and shutting down of the international travel either by air, land or sea to contain the viral transmission throughout the world. South Africa also implemented similar measures in regard to the international travel ban in March 2020.

The ban was not only on the travel between countries, but restrictions were also imposed between provinces and even with towns. The country implemented a complete shutdown on businesses, schools and all services with the exception of essential services such as retail and hospitals. The essential providers also operated under strict regulations to minimise the viral transmission.

The research looked at both private and public hospitals in Johannesburg and Ekurhuleni Metros in Gauteng province, South Africa. The study found variation in traffic flow patterns at each hospital investigated which was done by traffic and pedestrian count at the hospital access gate during the COVID-19 pandemic Lockdown Level 3. The study found that traffic at private hospitals was lower during the midday which was expected due to the regulations implemented by hospitals. The traffic during the morning was, however unusually, higher than the normal period prior COVID-19 pandemic lockdown.

Trip generation rates are used to estimate the number of trips produced and attracted by the hospitals. These trip generation rates are provided in the South African Trip Generation Rates and the South African Trip Data manuals which are based on the South African land use characteristics. The Institute of Transportation Engineers manual is also used mostly by international countries. The research found that the trip generation rates measured at both the private and public hospitals are lower than the trip generation rates recommended in the two existing local manuals. Similar results were established even

with the historical data received from the private hospitals records. It is possible that the vehicles trips estimated by the existing trip generation rates are an overestimate. Pedestrians' volumes (from Public Transport) at public hospitals were almost 80% of the vehicle volumes, signifying a high percentage of pedestrians and lower vehicle ownership.

Due to the virus rapidly spreading throughout the country, it was expected that the parking demand at hospitals would be higher with patients seeking medical assistance. The research however found that the parking demand was very low and this could be as a result of strict regulations for hospital visits and travel restrictions during the lockdown.

Overall, it was concluded that COVID-19 pandemic and the imposed restrictions had an impact on hospital traffic generation and the parking demand. The traffic flow patterns were slightly lower compared to the time before COVID-19. The parking demand was less due to the restrictions and the additional parking time due to screening had an insignificant impact on the parking demand.

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CONTENTS

LIST OF ACRONYMS

COVID-19	Corona Virus Disease 2019
SATGR	South African Trip Generation Rates
COTO	Committee of Transport Officials
ITE	Institute of transport Engineers
TMH	Technical Methods for Highways
GLA	Gross Leasable Area
GFA	Gross Floor Area
SF	Square Foot
VMT	Vehicle Miles Travelled

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1. INTRODUCTION

1.1 Background

The COVID-19 pandemic outbreak has caused a considerable impact on the travel behaviour in many cities globally. COVID-19 is the disease caused by a new Coronavirus. Coronaviruses are a large family of viruses which may cause respiratory infections ranging from the common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS). The most recent Coronavirus disease is COVID-19 (Republic of South Africa Health Department, 2020).

On 30 January, 2020, the World Health Organization (WHO) declared COVID-19 a public health emergency of international concern. Since erupting in China, it has claimed thousands of lives there, and has now spread globally, causing infections, deaths and growing alarm (World Health Organization, 2020). The relevant need to limit the transmission of the virus by putting a halt to human mobility was clear as the disease spread throughout the world. This resulted in the global travel ban on international air, sea and land passenger traffic.

In response to the COVID-19 pandemic and to reduce the virus infection rate, the South African government imposed several measures. The government implemented lockdown restrictions which began with the international travel ban and local travel limitations on 26 March 2020. The governmental directives also required people to maintain physical social distancing from one another, and for all persons to wear masks when outside of their homes. A forced shutdown of all services was implemented requiring people to work from home, and only the essential services providers, such as hospitals and food retail, were allowed to operate.

The South African lockdown was imposed over time and at different lockdown Alert Levels, starting with Alert Level 5 to Alert Level 1, Alert Level 5 being the total shutdown of all but essential services and restrictions easing up to Alert Level 1. During the Alert Level 5, travelling between provinces within South Africa was banned; people were only allowed to travel within their district of residence and within the prescribed distance from

their places of residence. The lockdown restrictions also required people to travel only for the purpose of medical and essential needs. Public transport was also subject to travel restrictions; however municipal buses and taxis were allowed to operate during certain times of the day and at reduced capacity.

1.2 Purpose of Study

A study of Wuhan hospitals conducted via the satellite imagery obtained between October 2018 and February 2020 revealed that there was more traffic at the hospitals parking at the early indication of the COVID-19 outbreak (Okanyene, NE et al., 2020). This study however could not conclude whether the increase in hospital traffic was as a result of COVID-19 pandemic since the outbreak was only reported to WHO in December 2019.

Any type of land use or development has the potential to generate traffic. The traffic generation varies through the day depending on the services offered by the land use type. An example will be an office land use which generates higher inbound traffic volumes during the morning when employees come to work and higher outbound traffic during the afternoon when employees go back home, then lesser traffic during the day with mostly visitors and deliveries. The land use will also need parking provision for staff, visitors and deliveries.

The traffic that flows in and out of a hospital land use also varies during the day and may differ per hospital, depending on the size, capacity and services provided. Hospital traffic will comprise of trips made by doctors, nurses, general employees, patients, visitors and deliveries. Based on the purpose of the trip maker to the hospital, the inbound and outbound traffic flow movement varies throughout the day per hospital. The traffic patterns may also be affected by the working times of the hospital staff, operational times of the specialists, doctors and allowed visiting hours to hospitalised patients. Hospitals require parking for hospital employees, visitors and deliveries which should be provided for depending on the hospital size.

The traffic and parking generation for each land use are predicted according to specific land-use elements such as the size of the development, Gross Leasable Area (GLA per

100 m^2) of the building, number of employees, etc. These elements are independent variables used to estimate and establish the trip generation. In South Africa, there are manuals that provide trip generation and parking generation indicators. These manuals, South African Trip Generation Rates manual (Stander, H et al., 1995) and TMH 17, South African Trip Data manual (Committee of Transport Officials, 2012) are based on surveys at existing hospital land use. Trip generation and parking generation indicators for hospitals are mainly based on the number of hospital beds and Gross Leasable Area (GLA per 100 m^2).

The purpose of this research is to investigate the impact of the COVID-19 pandemic on hospital traffic as well as the parking demand during the pandemic. Due to COVID-19 and the high infection rate, some of the hospitals implemented restrictions on day-to-day hospital operations. COVID-19 is highly contagious, and the virus could transfer from the administering doctor to a patient or vice versa very easily. Patient in-person consultations were not recommended and patients were encouraged to make use of the tele-consultation. Visitations of any hospitalised patients by families and friends were suspended and restricted to emergency purposes.

Comparing the traffic flow patterns during COVID-19 pandemic and the information before the pandemic will provide valuable information on how hospitals can better prepare for the future pandemics regarding the traffic flow patterns. It will also provide a review of the existing trip generation indicators.

1.3 Problem Statement

This study aims to investigate the impact of COVID-19 pandemic on the hospital traffic and the associated parking demand. Due to high transmission of COVID-19 doctors, nurses and other hospital employees who have contracted the virus were forced to self-isolate or quarantine at home. Visitors were also not allowed at hospitals. It is therefore, expected that the pandemic will have had an observable impact on hospital traffic flow patterns.

The safety regulations at hospitals included screening of both patients and hospital employees before they were cleared to enter the hospital building. The screening adds additional time to the time spent at hospital by patients, which may also have impact on the parking duration and demand. COVID-19 pandemic is a new outbreak which caught the world unprepared and therefore has had a huge impact across all spectrums of life. The study is hoping to find answers on the impact of COVID-19 pandemic on hospital traffic and parking demand, and how hospitals could better prepare for similar outbreaks in the future.

1.4 Research Objectives

The aim of this research is:

- To investigate the impact of COVID-19 pandemic on the hospital traffic flow patterns, focusing on both private and public hospitals within the City of Johannesburg and Ekurhuleni Metros, in Gauteng, South Africa. The changes in overall traffic volume patterns at hospitals and the data collected during the pandemic will be compared with data prior the pandemic (where data is available).
- To investigate the difference if any, on the existing trip generation and parking generation indicators. These will be compared to the current recommended trip generation rates by the South African Trip Generation Rates (Stander, H et al., 1995), South African Trip Data (South Africa Committee of Transport Officials, 2012) and the Institute of transportation Engineers (Institute of Transport Engineers, 1997) manuals which applies to the normal conditions with no travel restrictions.
- To determine the impact of the screening process at the hospital on the parking time and demand. Does the screening have any impact on the availability of parking for both employees and patients due to additional parking duration?

1.5 Assumptions and Limitations

The following are the assumptions and limitations relevant to this research:

- The project only focuses on private and public hospitals within the Johannesburg and Ekurhuleni metros, in Gauteng Province, South Africa.

- The traffic count at hospitals will only be done for all vehicle trips and pedestrians but will not differentiate the public transport trips such as Uber and Taxify. Only vehicles entering and exiting the hospital sites were counted. Mostly, public transport vehicles drop off passengers in the roads around the hospital and these passengers walk the rest of the way to the hospital entrances. Because of the difficulty in seeing all public transport vehicles and determining if the public transport vehicle was dropping off or picking up passengers that were coming from or going to the hospital, it was decided to not count public transport vehicles. Pedestrians walking through the gates at hospitals were however counted, therefore accounting for public transport trips.

1.6 Research Outline

The research is presented in six chapters which are outlined below:

Chapter 1: Introduction

This chapter provides background to the research. It presents the general overview of COVID-19 pandemic and the response of international and local authorities to the pandemic. The research problems and objectives are introduced including the theoretical considerations in terms of traffic flows, trip generation and parking indicators. This chapter outlines the framework of the research.

Chapter 2: Literature Review

This chapter provides an overview of literature consulted in this research study. It includes an overview of COVID-19 pandemic impact on mobility in general, both in South Africa and globally. The impact of imposed restrictions on travel patterns locally including the effects of hard lockdown on both essential and non-essential providers was assessed. The influence of restrictions on hospital traffic flows as an essential provider in relation to the viral cases and governmental directives. The existing trip generation indicators and parking demands for hospital land use.

Chapter 3: Methodology

This chapter describes the methods that the research used in investigating the impact of COVID-19 pandemic on the hospital traffic flow and parking demand. The research method is explained by defining the strategy, data collection, data analysis, limitations and ethical consideration.

Chapter 4: Study Area

The study area in terms of the local surroundings to each hospital and the available transport facilities immediate to the hospital are discussed in this chapter.

Chapter 5: Results and Discussion

The results of data collected via traffic count and questionnaires are described and summarised in this chapter. It provides a comparison of the COVID-19 pandemic data with the data obtained for before COVID-19 pandemic period.

Chapter 6: Conclusions and Recommendations

This chapter presents the conclusions drawn from the findings of this research that investigated the impact of COVID-19 pandemic on hospital traffic flows. The recommendations for future research are also made from the research limitations.

2. LITERATURE REVIEW

2.1 Background

At the close of 2019, the WHO China Country Office was informed of pneumonia of unknown cause, detected in the city of Wuhan in Hubei province, China. According to the authorities, some patients were operating dealers or vendors in the Huanan Seafood market. Staying in close contact with national authorities, WHO began monitoring the situation and requested further information on the laboratory tests performed and the different diagnoses considered (World Health Organization, 2020).

WHO defines Coronavirus disease (COVID-19) as an infectious disease caused by a newly discovered coronavirus (World Health Organization, 2020). Most people infected with the COVID-19 virus will experience mild to moderate respiratory illness and recover without requiring special treatment. Older people, and those with underlying medical problems like cardiovascular disease, diabetes, chronic respiratory disease, and cancer are more likely to develop serious illness (World Health Organization, 2020).

The lack of vaccines or specific treatments for COVID-19 did not help combat the virus; the virus was rapidly spreading throughout the world. The international and local communities resolved to complete lockdown and closure of borders in an effort to contain the global spread of the virus. To prevent and minimise the transmission it was recommended that people be well informed about the COVID-19 virus, how the virus spreads and the other diseases caused by the virus. To protect oneself from being infected by the virus, it was recommended that people practice social distancing and proper hygiene etiquette by frequent washing of hands and using alcohol-based sanitizer.

2.2 COVID-19 Pandemic in South Africa

National Institute for Communicable Diseases in South Africa confirmed a suspected case of COVID-19 for a citizen who tested positive in March 5, 2020 (National Institute for Communicable Disease, 2020). The citizen tested positive to COVID-19 virus a few days after returning into the country from Europe. The patient was immediately put in

isolation and other citizens who were in contact with the said patient zero. Most cases occurred in people with close physical contact to positive patients and healthcare workers caring for patients with COVID-19 (Republic of South Africa Health Department, 2020).

The rapid increase in number of infected people globally and amongst the SA communities forced government to implement drastic lockdown measures by closure of schools, businesses and shutdown on all service providers with the exception of essential service providers. South African government declared a national state of emergency disaster on March 15, 2020 and formed a national COVID-19 command council headed by President Cyril Ramaphosa (National Institute for Communicable Disease, 2020)

On March 27 2020 the National Command Council (NCC) through President Ramaphosa declared the first 21-day national lockdown. The activities of the national COVID-19 command council were supported by a Ministerial Advisory Committee, composed of 44 eminent scientists with expertise and experience in laboratory testing, clinical matters, public health, and research. The committee synthesized available scientific evidence into user-friendly formats to facilitate evidence-informed decision-making by the command council (SAMRC, 2020).

2.2.1 Lockdown Levels and Regulations

Lockdown Alert Levels were based on the scientific risks strategies conducted by National Command Council (Refilwe Pitjeng, 2020). The lockdown levels and regulations for each level are briefly discussed below as listed on the Department of Health website.

- **Alert Level 5 (27/03/2020 to 30/04/2020):** Drastic measures were implemented to contain the spread of the virus to save lives. All public gatherings were prohibited and only essential services and essential service providers such as hospitals, supermarkets and others were allowed to operate. Citizens were encouraged to stay home unless they were essential workers or needed to purchase essential goods such as food and medical products.

- **Alert Level 4 (01/05/2020 to 31/05/2020):** Some activities were allowed to resume subject to extreme precautions required to limit community transmission and outbreaks. All essential services plus a limited number of sectors with low rate of transmission and high economic or social value were allowed. A curfew between 07:00 PM to 05:00 AM was implemented.
- **Alert Level 3 (01/06/2020 to 17/08/2020):** It involved the easing of some restrictions, including work and social activities, to address a high risk of transmission. A wider range of sectors with a low to moderate risk of transmission were permitted to operate. Citizens were encouraged to stay home to the greatest extend and limit their interactions with others. All public gatherings were still prohibited. All the data collection for this research study was conducted during this level.

  Inter-provincial movement was prohibited in all the above-mentioned lockdown levels.
- **Alert Level 2 (18/08/2020 to 20/09/2020):** It involved further easing of restrictions, but the maintenance of physical social distancing and restrictions on some leisure and social activities remained to prevent a resurgence of the virus. All retail services were permitted; restaurants and fast food outlets could open only for delivery and take away. Citizens were still encouraged to stay home to the greatest extend and limit the interaction with other people. Movement between provinces was allowed, except for provinces with higher infection levels.
- **Alert Level 1 (21/09/2020 to present):** Most normal activity could resume, with precautions and health guidelines followed at all times. All sectors were permitted to operate and businesses such as restaurants would have to operate with strict social distancing measures. All public gatherings were allowed with strict regulations.

Figure 2-1 below shows the South African Lockdown Alert Levels as given by government through the command centre.

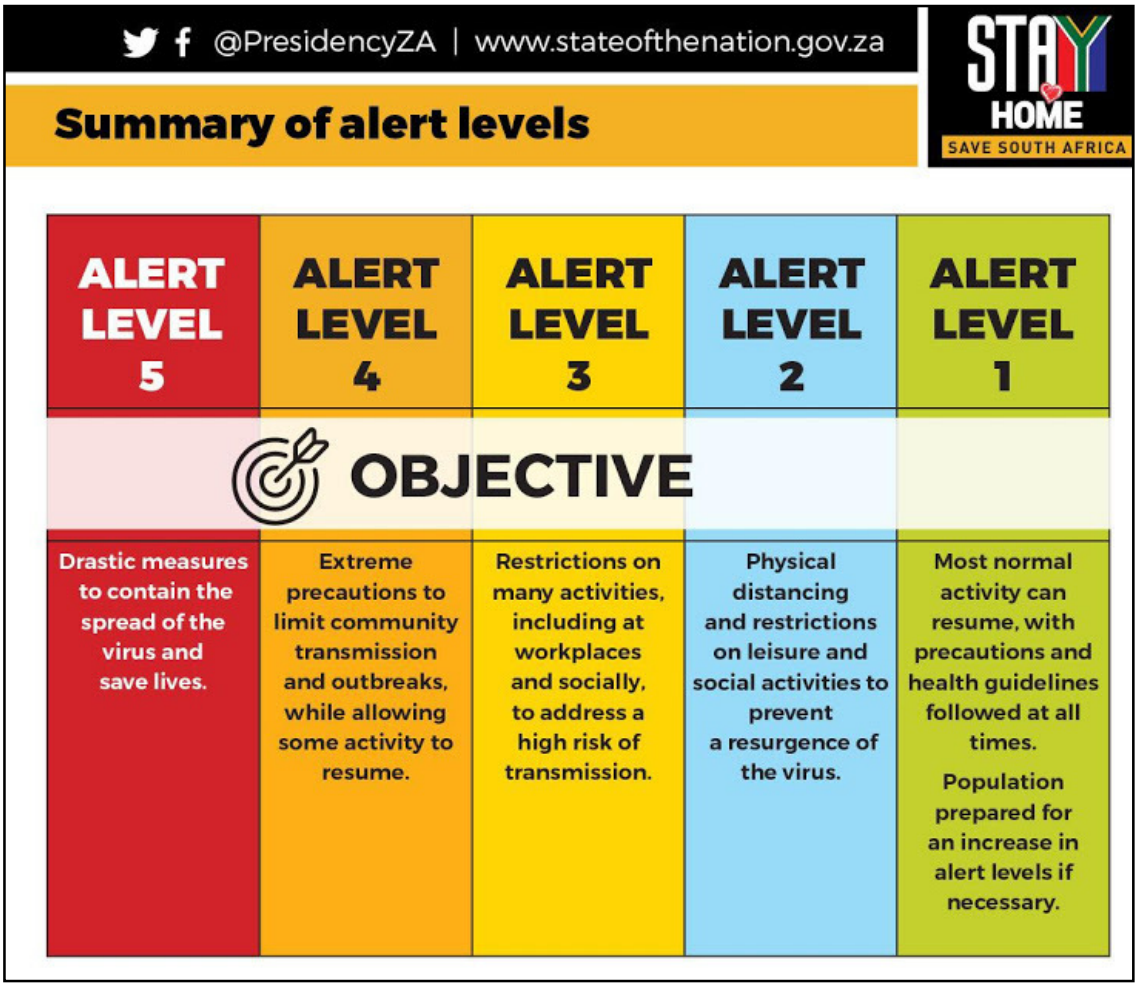


Figure 2-1: South African Lockdown Alert Levels (South African Government, 2020)

2.2.2 Varying Traffic Congestion during the Lockdown

The level of road congestion during COVID-19 Lockdown in South Africa was obtained from TomTom website. TomTom is the leading location technology specialist, shaping mobility with highly accurate maps, navigation software, real-time traffic information and services (www.tomtom.com).

The TomTom traffic index is a measure of traffic congestion. The level of congestion is given in percentages and indicate travel time. A 20% congestion level means an hour trip would take 20% more travel time due to the traffic congestion. An hour trip (60 minutes) and 20% congestion level means 60 x 0.2 = 12 minutes, additional travel time due to congestion.

The congestion patterns provided by TomTom in major South African cities such as Pretoria and Cape Town show similar congestion patterns in the various cities during 2020, and the impact of COVID-19 pandemic. The traffic data for City of Johannesburg in Gauteng was used for the purpose of this research study. The colour-coded figures as shown in **Figure 2-2** below are based on levels of congestion measurements from TomTom's historical traffic database (TomTom, 2020).

Week 1-2: 30 Dec 2019 – 12 Jan 2020 – shows beginning of year traffic with majority of the workforce still on holiday. The average congestion ranges between 13 – 27% during the normal working day (Monday to Friday).

Week 3 - 13: 6 Jan 2020 – 13 March 2020 - shows that traffic went back to normal with most of the workforce back to work. The average congestion ranged between 40 - 47% during the weekday. During this period, some of the citizens were found to be COVID-19 positive and the number of infected cases was rising. Many people were growing weary of travelling and interacting with each other. This is reflected by a significant drop in road traffic congestions for week 12 and 13. Week 13, President Cyril Ramaphosa announced the first Lockdown Alert Level 5 for 21 days and the shutdown of businesses and schools which began on Thursday 26 March.

Week 14 - 18: Lockdown Alert Level 5 shows a huge impact on traffic and congestion averaging 10-12%. During this period, everyone was encouraged to stay at home and only travel to buy essential food and medical products. On Thursday 30 April, the president announced the change from Lockdown Alert Level 5 to Alert Level 4 starting on Friday 01 May 2020.

Week 19 - 22: Lockdown Alert Level 4, all essential service providers and some of the services were allowed to operate. During this period traffic congestion increased and averaged between 12-15% during the normal working days. It was announced that starting from June 1 2020 the country would move from Lockdown Alert Level 4 to Alert Level 3.

Week 23 - 33: Monday 01 June began Lockdown Alert Level 3. More sectors were allowed to operate and there was ease on some restrictions while observing social

distancing and some safety considerations. The traffic congestion increased to an average of 16 -19%.

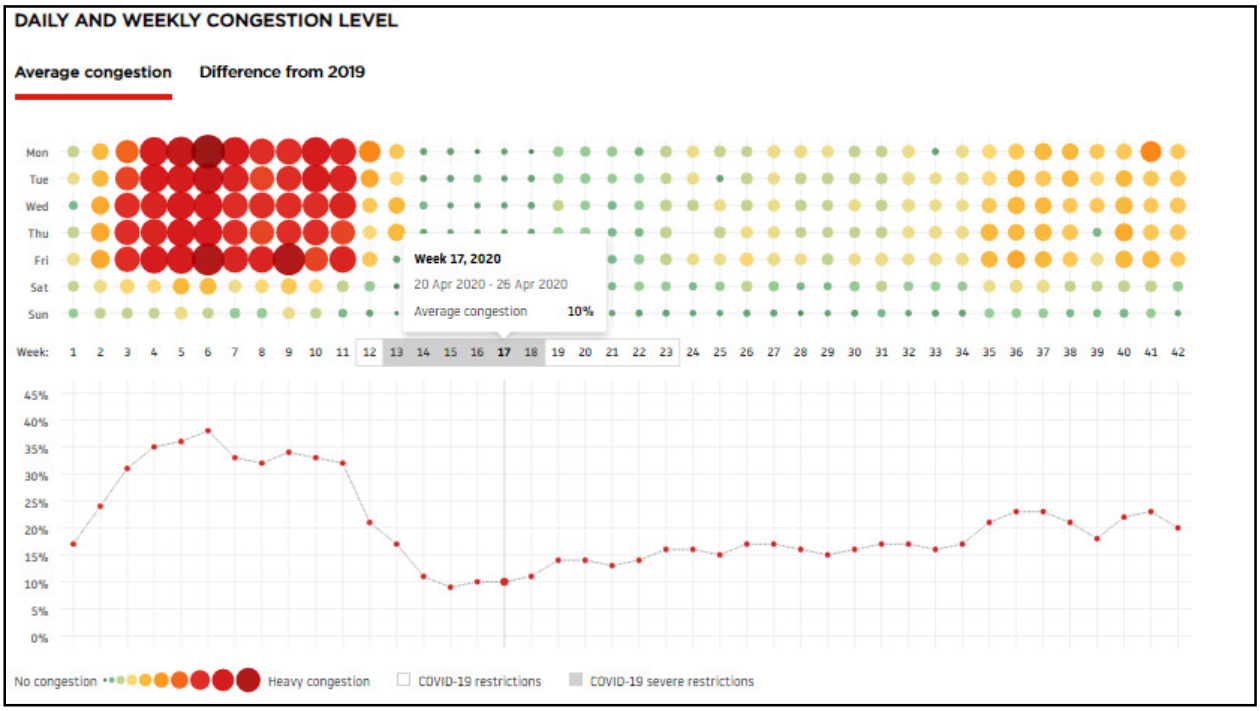


Figure 2-2 : Level of Congestion on Johannesburg Roads (TomTom, 2020)

Week 34 – 42: The country moved to Lockdown Alert Level 2 on Monday 18 August 2020. It can be seen that the percentage of congestion on the roads went higher ranging between 21-26% during the weekday. In September 21 2020, the government announced a movement to Lockdown Alert Level 1. This started on week 39 on Figure 2-2 above. Although the Lockdown Alert Level 1 meant all services opened for operation, it can be seen that there was no increase in traffic congestion on the roads. The traffic congestion remained similar to Lockdown Alert Level 2 congestions.

2.2.3 Comparison on Traffic Congestion between 2019 and 2020

Figure 2-3 below relates difference of average congestion levels in 2020 from standard congestion levels in 2019.

Week 1-2: 30 Dec 2019 – 12 Jan 2020 – shows that the traffic congestions in 2020 were far less than the standard daily traffic congestion. The highest being during week 1 with 43% less congestion during the normal weekday. The weekend traffic congestion saw a decrease of 12%.

Week 3 - 13: 6 Jan 2020 – 13 March 2020 shows that traffic went back to normal and the level of congestions were even 6% higher than the standard daily congestion during week 4. The level of congestion went up to 25% more during week 6. However, the levels of congestions decreased by 14% less than the normal daily standard, and decreased by 31% during week 12 which was a week before the lockdown was imposed. Further decrease in traffic congestion happened during week 13 which may suggest majority of citizens were already on self-imposed lockdown even prior to the country lockdown which started on the same week, Friday 27 March 2020.

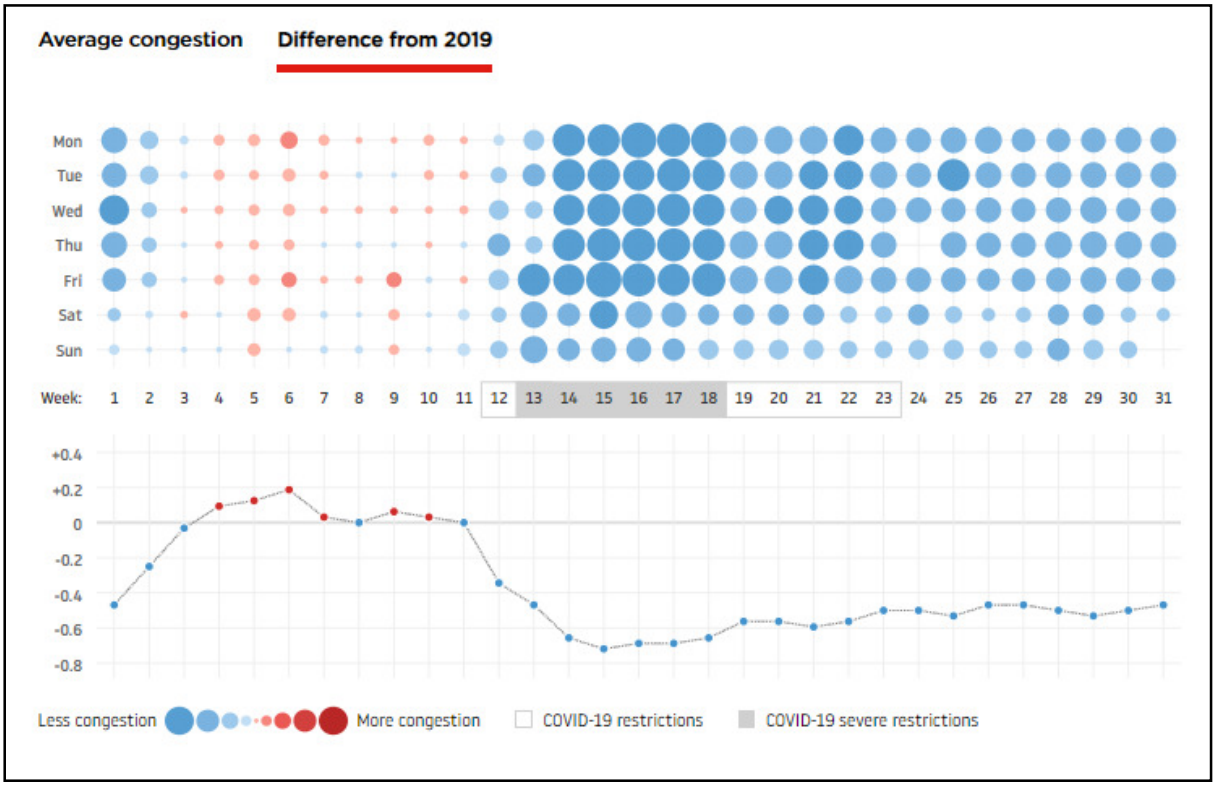


Figure 2-3 : Changes in Level of Congestion on Johannesburg Roads between 2020 and 219 (TomTom, 2020)

Week 14 - 18: Lockdown Alert Level 5 shows a huge impact on traffic congestion which was less by 69-72% during the weekday. This was due to the travel restrictions and

majority of people working from home. The traffic congestion was down by 40 – 55 % during the weekend which was unusual in comparison to the time period outside of the lockdown.

The increase in traffic congestion on Saturdays and Sundays during the lockdown could be attributed to people making a trip to the shops to acquire the essential food and medical supply. Whereas during normal days (Outside of the pandemic lockdown) some people would do shopping after work, during COVID-19 citizens were working from home and made no trips to work. Therefore, the ban on office work and curfews means people preferred to do shopping during the weekend.

Week 19 - 22: Lockdown Alert Level 4, the traffic congestions during this level were less than the standard daily congestion by 58 – 64% during the weekday and 31 – 40% during the weekend.

Week 23 - 31: Monday 01 June began Lockdown Alert Level 3. More sectors were allowed to operate and there was ease on some restrictions while observing social distancing and some safety considerations. Due to the traffic increase, the standard daily congestion decreased to an average of 47 - 54%.

2.3 COVID-19 Pandemic Globally

INRIX is a European company that manages traffic by analysing data not just from road sensors, but also from vehicles. INRIX conducted a study on European Passenger Travel Response to COVID-19 (INRIX RESEARCH, 2020). The study investigated the impact of COVID-19 by analysing the Vehicle Miles Travelled (VMT) in each country during the Lockdowns.

The report shows that the timing and the degree to which each country lockdown in response to the virus resulted in a significant variation of impact to the road network. The analysis compares the VMT before COVID-19 Lockdown, the VMT during Lockdown and the easing of the Lockdown. **Figure 2-4** below shows the percentage of VMT during COVID-19 to the VMT before COVID-19. The figure shows the data of Italy and two of its major cities, Rome and Milan.

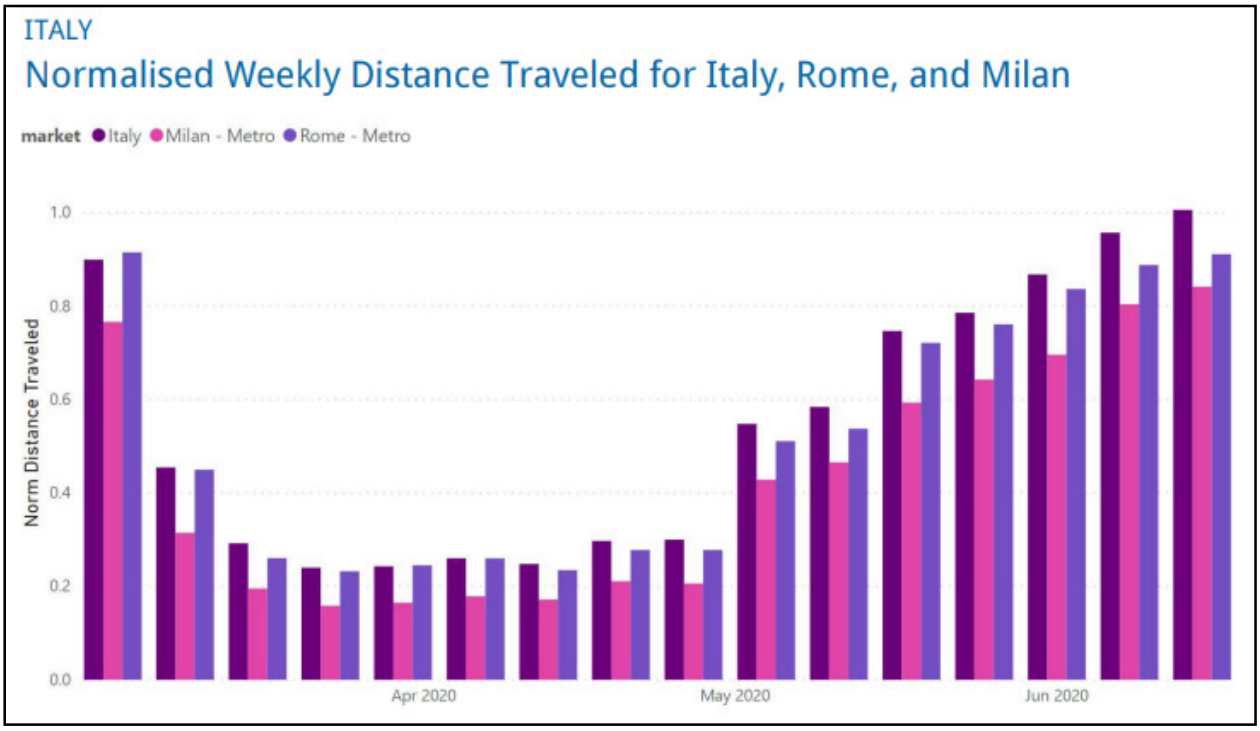


Figure 2-4: : Percentage Change in VMT in Italy (INRIX RESEARCH, 2020)

Based on the above information, Italy reached the lowest VMT of 24% of pre-COVID-19 level nationwide. Rome and Milan reached the low of 23% and 16% of pre-COVID levels respectively.

A similar analysis for Spain is shown in **Figure 2-5** below. The figure shows that Spain reached a low of distance travelled during the month of April. The report shows that the distance travelled reached a low of 12% of pre-COVID VMT. The cities of Barcelona and Madrid reached a low of 10% and 7% of pre-COVID VMT respectively.

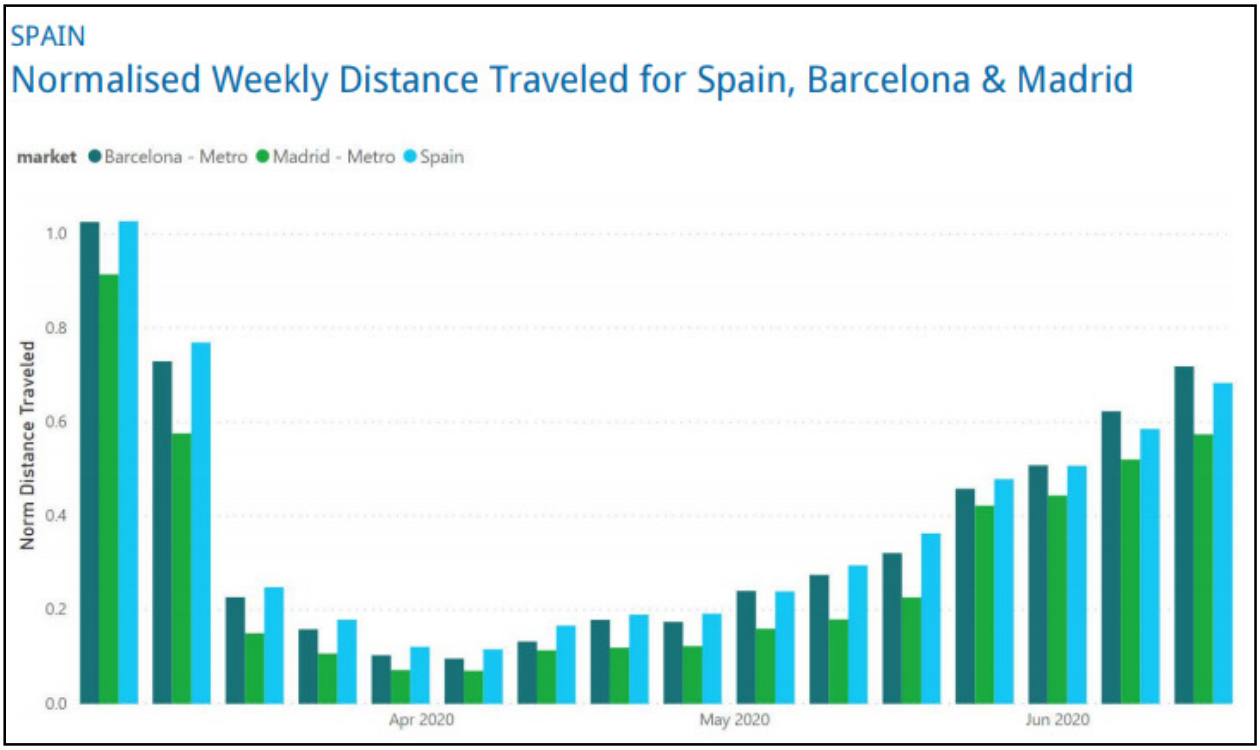


Figure 2-5: : Percentage Change in VMT in Spain (INRIX RESEARCH, 2020)

Figure 2-6 below shows the comparison of COVID-19 impact on miles travelled per country. It can be seen that Spain had the lowest miles travelled in March and Germany was the least affected.

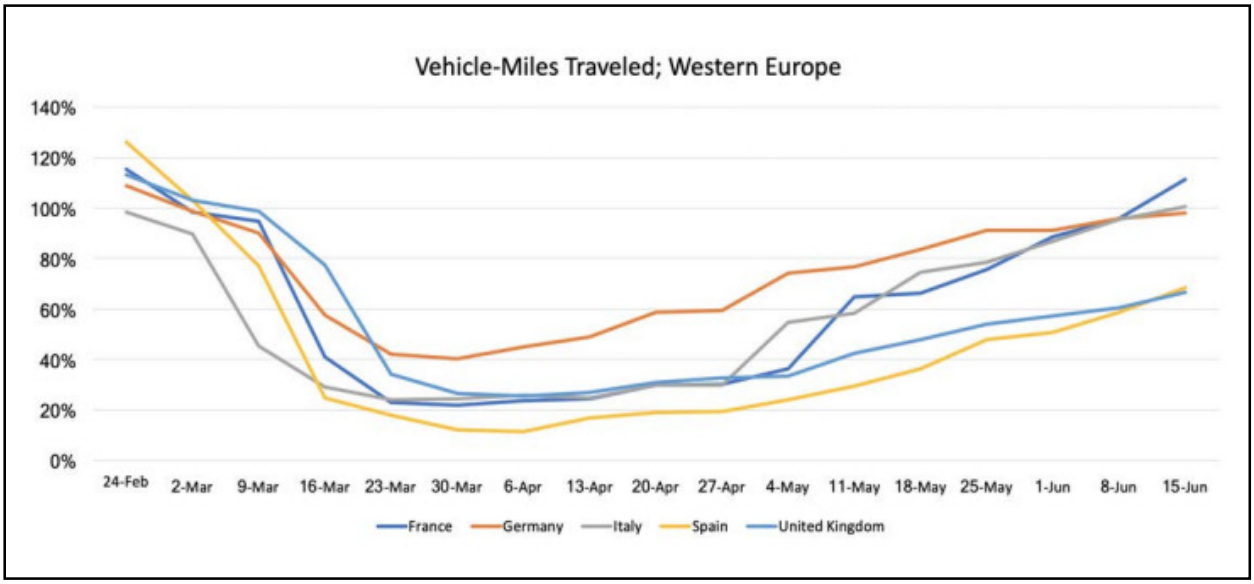


Figure 2-6: Percentage Change in VMT for five Western European countries (INRIX RESEARCH, 2020)

The report found that the VMT across Europe decreased significantly due to country lockdowns in attempt to slow the spread of COVID-19. The most impact on miles travelled happened between March and April 2020 depending on when was the lockdown restrictions imposed in each country.

2.4 Impact of COVID-19 Pandemic on SA Hospital traffic

In light of the South African lockdown restrictions by the Health Ministry, traffic flow patterns changed drastically. Hospitals were considered essential service providers and therefore were allowed to operate as normal. All the staff continued working without any changes to either working hours or services provided. Since people were only allowed to travel within 5 km of their residence, the hospital staffs were issued with permits for ease of travel between work and place of residence.

Some of the hospitals such as Medicross Health Care Group implemented the telehealth system to minimise the face-to face doctor consultations and visiting the hospitalised by patients. This can be found on their website when making an online booking. These strict

measures were implemented to minimise the transmission of virus between patients and hospital staff. According to the Eye Witness News, some private hospitals in Johannesburg South Africa suspended and/or restricted visiting hours in light of the COVID-19 pandemic effective from March 2020. An official letter on Netcare hospitals website stated that “All visiting of patients in general wards, ICU and high care units remain suspended” (Netcare, 2020).

An exception was given for Nursery and NICU where one parent at a time was allowed to visit new-borns or stay with an admitted child. Another exception was for critically ill patients and end of life situations where visitation by family members could be arranged with the hospital. The regulations were however constantly re-evaluated based on experience and learning during this pandemic in an effort to surge COVID-19 cases, to protect the healthcare teams and patients.

2.5 Impact of COVID-19 Pandemic on International Hospital traffic

The COVID-19 pandemic dramatically changed outpatient care delivery in health care practices globally. In an attempt to minimise the virus transmission between patient to patient or doctor to patient, most of the hospitals implemented restrictions on hospital visits. In other parts of Europe, the hospital visits were replaced by telehealth. To decrease the risk of transmitting the virus to either patients or health care workers within their practice, providers were deferring elective and preventive visits, such as annual physicals. Where possible, hospitals are also converting in-person visits to telemedicine visits (Mayo Clinic, 2020).

Telehealth is the use of digital information and communication technologies, such as computers and mobile devices, to access health care services remotely and manage your health care. These may be technologies used from home or that the doctor uses to improve or support health care services. Mayo Clinic Staff, telehealth (Mayo Clinic, 2020).

2.5.1 United States of America

Researchers at Harvard University and Phreesia, a health care technology company, analysed data on changes in visit volume for more than 50,000 medical care providers that are Phreesia clients. The research study period was between mid-February to mid-May and evaluated about 12 million visits in the United States of America.

- **A visit** was considered checked-in when either the patient or someone at the practice (such as a nursing assistant) filled in the necessary information using the Phreesia platform and the patient was ready to see the provider.
- **Telemedicine visits** were identified in the scheduling software based on the appointment type or location.

Based on the data analyses, it was found that the visits to healthcare providers decreased by almost 70% compared to the number of visits before the pandemic. Refer to **Figure 2-7** below for change in visits February and May in different states. It can also be seen that from the first week of April a rebound in visits started occurring in all areas of the United States, with the most considerable rebound in the South Central area.

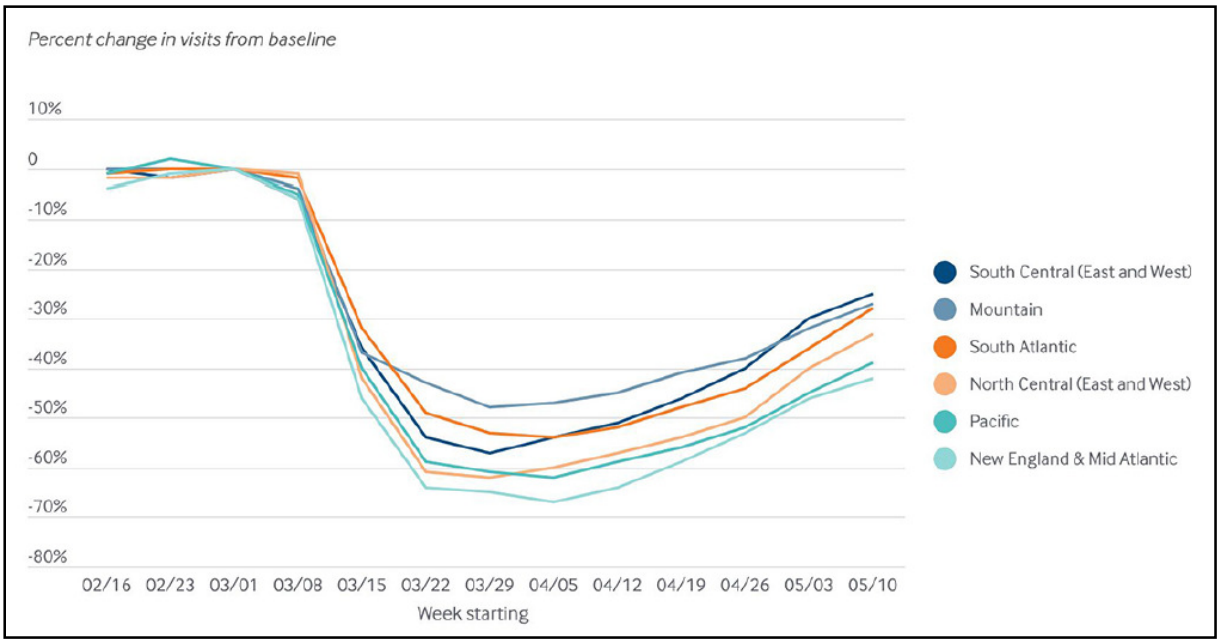


Figure 2-7: Percentage Change in Visits from baseline – (Ateev Mehrotra et al., 2020)

The decrease in patients' visits to healthcare providers would result in lower traffic flows to the hospital throughout the day. During the same period, patients and medical professionals making use of the telehealth system was observed to increase. Refer to **Figure 2-8** below for the graph showing the increase on telehealth visits. The telemedicine visits increased by approximately 14% compared to the period before the pandemic. In mid-April the telemedicine visits started declining which can also be related to the increase on in-visits as shown in Figure 2-7 above.

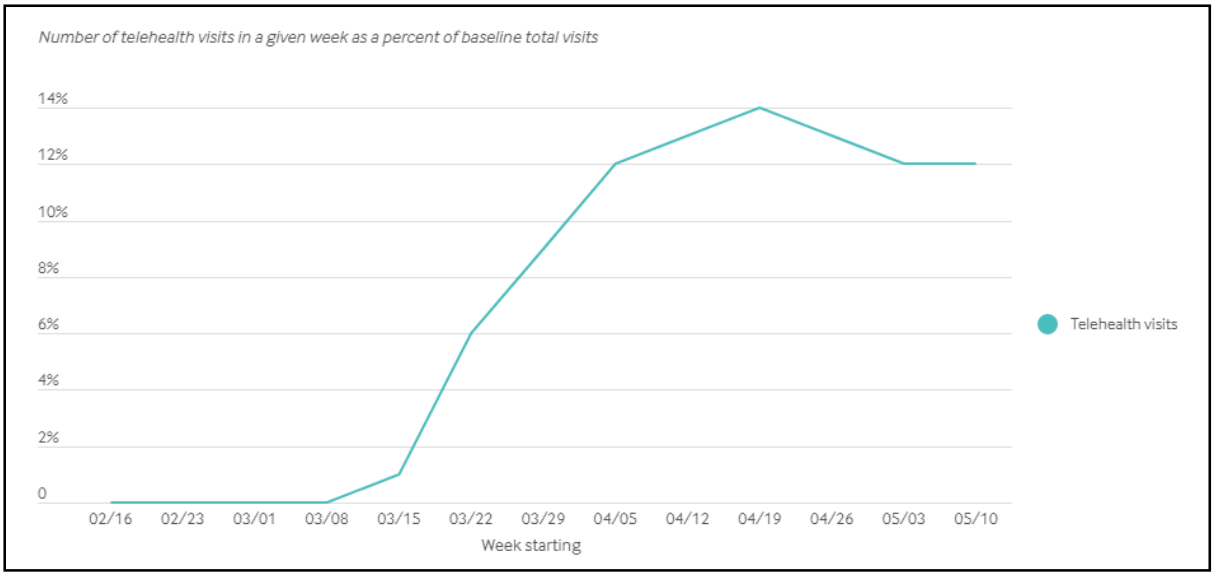


Figure 2-8: Number of Telehealth Visits as a percentage of baseline (Ateev Mehrotra et al., 2020)

2.5.2 Wuhan, China

On another study, the Harvard community conducted a research on hospital traffic in Wuhan, China, Nsoesie, E.O., Rader, B., Barnoon Y.L., Goodwin, L., and Brownstein, J.S.. Analysis of hospital traffic and search engine data in Wuhan China indicates early disease activity in the fall of 2019 (Okanyene, NE et al., 2020).

The research investigated the impact of COVID-19 pandemic on traffic at 6 hospitals in Wuhan, China. The researchers made use of satellite images at local hospitals before

China reported of COVID-19 disease to the World Health Organisation. Based on the report, the researchers obtained archived high-resolution imagery data for Wuhan, China from Remote Sensing Metrics (RS Metrics).

The researchers developed a comprehensive list of hospitals in Wuhan (using Google Maps, Wikipedia and PubMed) and used clinical data on reports of illnesses such as influenza-like and diarrhoea which are now known as part of symptoms for COVID-19. The researchers collected satellite images of Wuhan from January 9, 2018 to April 30, 2020 resulting in a successful daily extraction of parking lot volume from the 6 hospitals, see **Figure 2-9** below for the imagery data.

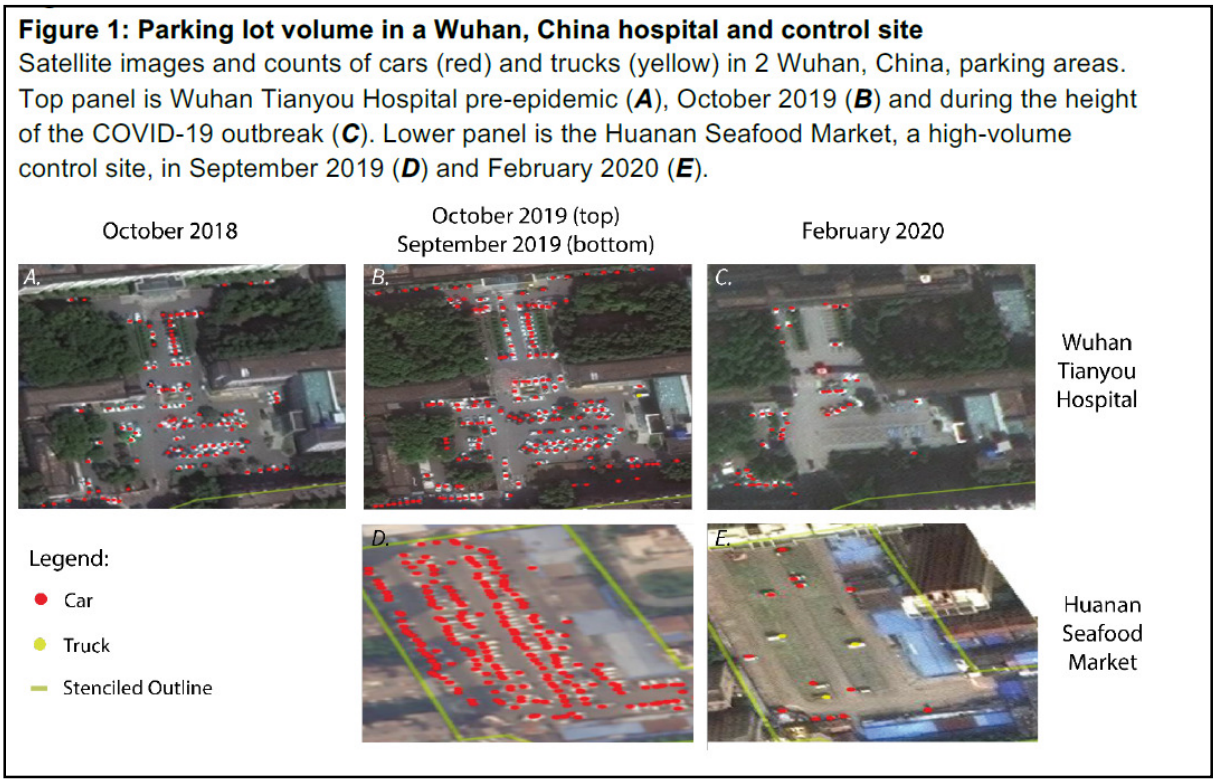


Figure 2-9: Parking lot volume in Wuhan hospitals between 2018 and 2020 (Okanyene, NE et al., 2020)

The imagery of Wuhan Tianyou Hospital in Figure 2-9 above shows that there was an increase in vehicles parked on the hospital parking lot and the streets surrounding the hospital in October 2019 compared to October 2018. Although the study could not confirm

if the increased volume was directly related to the new virus, it is clear that there were a high number of patients visiting the hospital in October 2019. A decline in the number of vehicles parked at the hospital parking lot can also be seen in frame c in February 2020, which was a period during the Wuhan city lockdown.

Figure 2-10 below shows the hospital traffic variation in relation to the illnesses in the period of May 2018 – May 2020. Although the number of confirmed COVID-19 cases shows a spike in December 2019 (2c), the increase in reported illnesses of influenza-like and diarrhoea can be seen to have spiked just weeks before the outbreak was confirmed and reported.

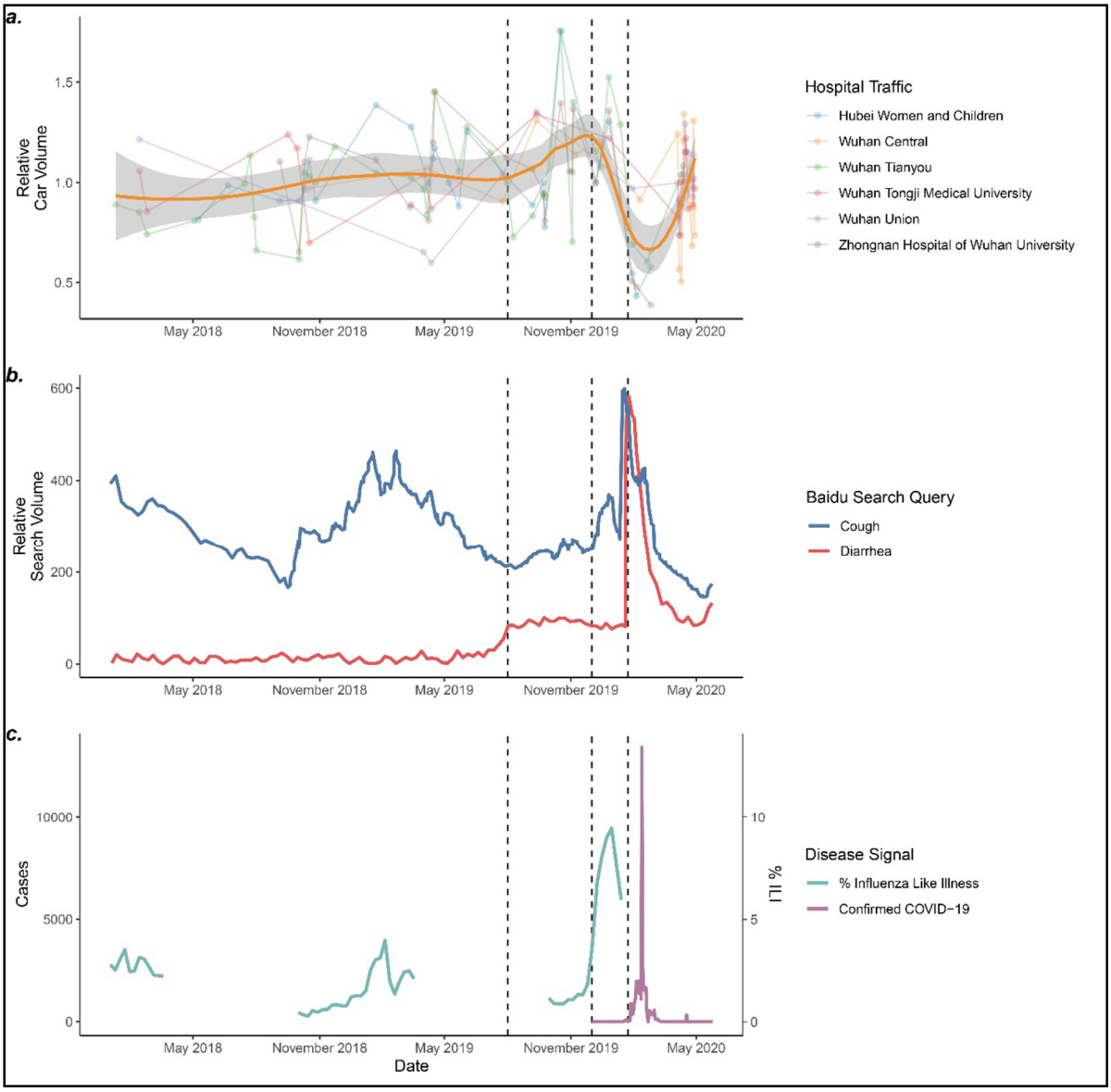


Figure 2-10: Variation of Hospital traffic and disease reported cases (Okanyene, NE et al., 2020)

2.6 Trip Generation Rates

Trip generation is the number of vehicle trips going in and out of the development, these trips are created by the land-use. Trip generation factors are used to estimate the trip generation, and these factors are determined exclusively for each type of land use. This process estimates the number of trips produced and attracted by the development included in the study. Trip generation factors are published for a country e.g. trip factors for South Africa and other trip generation factors can be used globally. Existing trip

generation factors are based on surveys from existing similar land uses. The traffic generation models usually follow a basic linear regression equation (Institute of Transport Engineers, 1997).

$$T = aX + b \qquad \text{(Equation 1)}$$

Where Number of trips generated (T) = Quantity of independent variables (a) *Trip Generation factor (X) and b is the y-intercept of the slope.

The following equation is also used to estimate the trip generation or number of trips per land use. These factors may also differ per time of the day, e.g. the morning trip generation may be higher or lower than the afternoon peak hour.

$$\text{Trip Generation Rate} = \frac{\text{Number of Trips Generated}}{\text{Independent Variable*}} \qquad \text{(Equation 2)}$$

Independent variables* for hospitals include:

- number of beds,
- Gross Leasable Area and
- Spaces per practitioners (consulting rooms)
- Number of Employees.

The South African Trip Generation Rates manual (SATGRM), second edition, 1995 is used as a basis for trip generation estimation throughout the country (Stander, H. et al., 1995). Trips at public hospitals are based on the number of beds as an independent variable. Trips to private hospitals are based on three possible independent variables which include number of beds, GLA or number of employees. There is a clear difference in trip generation at public hospitals and private hospitals. The manual shows lower trip generation factors per bed for private hospitals compared to public hospitals. Public hospitals not only differ from private hospitals by ownership, but also in the type of services and a socio-economic class of patients, which may influence the trip

characteristics (Stander, H et al., 1995). See **Table 2-1** below for the trip generation rates used in South Africa and those used globally (Institute of Transport Engineers, 1997).

Trip generation estimation, especially for public hospitals, is based on the number of hospital beds. It has been observed, however, that each hospital has a range of services including pharmacy, doctor's consultation rooms, clinic, and many more services. These services may have impact on the estimation of trip generation for hospital land use, and this study aims to establish the effect that each facility has on the overall trip generation factors. The trip generation factors by (Stander, et al., 1995) were based on surveys made at existing hospitals. The facilities within the hospitals may have changed with time, and more or fewer services are now offered based on the hospital's needs. For instance, some hospitals also provide accommodation for nurses and doctors, and the impact thereof on trip generation estimation may be significant. Others have educational training facilities which may also have an impact on the trip generation. The socio-economic status of the surrounding area could also have an impact on the trip generation. The medical staffs have different working shifts, and these shifts could fall outside of the normal peak period, and even the site street generator.

A more recent trip generation manual, TMH 16 Volume 1, South African Trip Data Manual (South Africa Committee of Transport Officials, 2012) also provides trip generation factors for both private and public hospital land use. The indicators in this manual recommend lower trip generation factors compared to the SATGR manual. The trip generation factors for private hospitals in this manual are based on GLA and exclude the other two independent variables, number of hospital beds, and number of employees. The use of the building size (GLA) includes trips generated by each service provided at the hospital. However, it is not clear to what extent each service would have an impact on the trip generation estimation.

Table 2-1: Summary of Existing Trip Generation Rates for the Hospitals

South African Trip Generation Rates (Stander, et al., 1995)				
Private Hospital	**Peak Hour**	**Average Rates**	**Recommended**	**Range**
Trip Generation per GLA (100 m^2)	AM	1,80	2,10	1,53 - 2,12
	PM	2,30	2,40	2,16 - 2,36
Trip Generation per bed	AM	1,30	1,30	1,23 - 1,36
	PM	1,80	2,10	1,37 - 2,25
Trip Generation per Employee	AM	0,50	0,50	0,45 - 0,57
	PM	0,70	0,80	0,51 - 0,81
Provincial Hospital				
Trip Generation per bed	AM	1,50	2,10	0,86 - 2,18
	PM	1,70	2,60	0,69 - 2,65
South African Trip Data Manual, TMH 17 (COTO 2012)				
Private Hospital		**Average Rates**	**Recommended**	**Range**
Trip Generation per GLA (100 m^2)	AM	N/A	1,65	N/A
	PM	N/A	1,50	N/A
Provincial Hospital				
Trip Generation per bed	AM	N/A	1,50	N/A
	PM	N/A	1,45	N/A
Institute of Transportation Engineers (1997)				
Hospital		**Average Rates**	**Recommended**	**Range**
Trip Generation per GFA (SF)	AM	1,20	N/A	0,94 - 1,63
	PM	1,46	N/A	0,87 - 3,38
Trip Generation per bed	AM	1,18	N/A	0,64 - 1,85
	PM	1,41	N/A	0,80 - 2,38
Trip Generation per Employees	AM	0,35	N/A	0,23 - 0,59
	PM	0,46	N/A	0,21 - 1,16

GLA – Gross Leasable Area, GFA - Gross Floor Area, SF - Square Foot

Trip generation factors from “The Institute of Transportation Engineers” (ITE) Trip Generation manual, 6th Edition, 1997 (Institute of Transport Engineers, 1997) are also considered in South Africa and globally. Although this manual is used worldwide, it is based on data from the United States of America and care needs to be taken when using this manual as the location and socioeconomic characteristics in the USA may differ greatly with other parts of the world. This manual does not distinguish between private and public hospitals. The trip generation factors in this manual are based on similar independent variables being the number of beds, the number of employees, and the Gross Floor Area. The manual provides a range of trip generation factors per independent

variable, and these can be used to interpolate the trip factor for the relevant land use size under investigation.

2.7 Parking Generation Rates

Parking provision is a requirement for all types of land use, and parking can be provided either on-street or off-street. The parking generation factors are based on independent variables such as the size of a building (Gross Leasable Area) or the number of dwelling units. The Department of Transport, Parking Standards, Second Edition (Van Zyl V. & Stander, 1985) is widely used as a source for individual land use parking generation rates in South Africa. This manual recommends number of beds as a basis for hospital land use parking generation rates. A parking generation rate of 1 parking space per bed is listed as a minimum requirement for both private and public hospitals. This standard includes parking for the doctors and other employees (Van Zyl V. & Stander, 1985). This parking provision is not sufficient to accommodate the hospital personnel, visitors to the hospital and other services provided per hospital need. Off-Street parking is desirable, especially in urban areas where traffic flows on adjacent streets are high. The manual also suggests that sufficient number of off-street parking must be provided at all the different types of development in urban areas.

3. RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

The aim of this project is to determine the impact of the COVID-19 pandemic on hospital traffic and parking demand in South Africa. To understand these objectives, this research used both quantitative and qualitative methods. The study makes use of both primary (traffic surveys and hospital interviews) and secondary (information from hospitals) source of data. The quantitative data (counted traffic) analysis and results are validated by the qualitative data (Infrastructural data such as number of beds) sourced.

The study involved collecting land-use characteristics such as the Gross Leasable Area (GLA) and conducting manual traffic counts at each hospital access during the peak periods. This chapter discusses the study area, data sources and sampling techniques used in the research.

3.2 Research Design

Traffic at several existing public and private hospitals in Gauteng province, in Johannesburg and Ekurhuleni, South Africa were investigated. Institutions were chosen based on size and location, and to ensure an even spread between public and private hospitals. Six institutions were investigated in this research and are listed below:

Public Hospitals

- Helen Joseph Hospital.
- Edenvale Hospital.
- Tambo Memorial Hospital.

Private Hospitals

- Three Private hospitals were also identified within Gauteng Province. The hospitals Research Committee requested that the hospital names not be identified in this research project.

3.3 Data sources

Data are those pieces of information that any particular situation gives to an observer, (Leedy and Ormrod, 2015). Data for this research was collected using a combination of primary and secondary sources. (Hox and Boeije, 2005) describe primary data as data that are collected for the specific research problem at hand, using the procedures that fit the research problem and secondary data as data originally collected for a different purpose and reused for another research question.

3.3.1 Primary data source

The primary data for this research was collected on-site at each hospital. The primary data source was manual traffic count at operational accesses to hospitals and interviews of the hospital representatives. The primary data collected was considered more reliable and offered more level of confidence since the researcher had direct contact with the occurrence of the events.

3.3.2 Secondary data source

Desk review has been conducted to collect data from various secondary sources. This includes local authorities and transportation industry manuals, reports, and some management documents which were included under the desk review. Information was also sourced from reputable books, journals, different articles, newsletters, newspapers, websites, and other sources in the transportation industry.

This includes information from recent Traffic Impact Studies for both private and public hospitals which were sourced from the traffic and transportation engineering consultancies as well as local municipalities. The data sought was for projects that have been approved by the local municipalities. The preferred information was specifically for existing hospitals which were being upgraded. This information would reflect the existing traffic flow patterns and the expected future hospital traffic due to the new upgrading.

The data also obtained from the existing working documents, manuals, procedures, reports, statistical data, policies, regulations, and standards were taken into account for

the research. In general, for this research study, the desk review has been completed to this end based on manuals and documents obtained from the selected companies.

3.4 Research Instruments

Primary data sources are qualitative and quantitative. The qualitative sources are field observation, interview, and informal discussions. The research instruments used for this research include personal interviews of hospital representatives by the researcher. Quantitative data sources are manual traffic and pedestrian counts at the hospital access gates. Observational research findings are considered strong in validity because the researcher is able to collect in depth information about a particular behaviour. In this dissertation, the researcher used the observation method as one tool for collecting information and data, as well as questionnaire design.

The information was recorded manually on paper and does not include any voice or other forms of recording. Each hospital was asked to nominate a representative who would be in a position to provide general information about the hospital or source the information from the relevant department. The next sections elaborate how the data were obtained from the primary sources.

The surveys were conducted in the following method:

- Personal interviews conducted with the representative of each hospital
- A questionnaire form completed by the representative of the hospital, providing the land use characteristics of the hospital and the factors that affect the hospital trip and parking demand.
- Classified traffic count at the access gates of each hospital
- Observations of the available parking spaces within the hospital premises

3.4.1 Personal interviews with the Hospital Management

The semi-structured interview is usually conducted in a face-to-face setting which permits the researcher to seek more insights, ask questions, and assess phenomena in different perspectives. It let the researcher to know the in-depth of the present working

environment, influential factors and consequences. Due to the Covid-19 pandemic there were restrictions on person contact and requirements to observe social distancing. Therefore, the main tool for gaining primary information in this research was a questionnaire, which allowed the researcher to decide on the sample and the types of questions to be asked.

It was preferred to do the information gathering telephonically or via email as opposed to face-to-face personal interviews. The initial communication in a form of a questionnaire enquiring about the land use characteristics was first provided to the representative via email. The follow up to the email was done telephonically to answer any questions deemed unclear. The information about the existing hospital size in terms of number of beds, consulting rooms, working shifts, number of employees was to be gathered from the hospital representative.

See Appendix A for the questionnaire. In instances where the representative preferred to provide information in person, a scheduled meeting was organised. The interviews were conducted at times convenient to the hospital representatives. This provided opportunities for refining data collection efforts and examining the information provided. It also assisted when the researcher faced written records or published document limitation or wanted to triangulate the data obtained from other primary and secondary data sources. Consequently, the questionnaire produced valuable data which was required to achieve the dissertation objectives.

3.4.2 Manual Classified Traffic Count Surveys

Observation is an important aspect of science and it is tightly connected to data collection. In order to observe and analyse the impact of COVID-19 on hospital traffic, it was required to conduct a manual traffic count at each participating hospital. The observation included both vehicles and pedestrians going in and out of the hospital site. Both vehicle and pedestrian data collection did not differentiate between the hospital employees, and hospital patients or visitors.

Initially, eight hospitals were selected for the research study, four private and four public hospitals. Permission was granted at all four private hospitals and only three public hospitals granted permission for the research to take place at their institutions. Manual counts were conducted at six of the eight selected hospitals, three private hospitals and three public hospitals because one of the private hospitals that had originally granted permission pulled out of the research study during the data collection period. The vehicle traffic counts did not include number plate capturing (no vehicles or occupants were identified) and did not have any impact on the daily operations of the hospital.

The traffic counts captured the number of vehicles and pedestrians going into the hospital premises and out of the hospital during specific day times. The surveys were conducted during the weekdays including Tuesday, Wednesday, and Thursday. Surveys were conducted during the COVID-19 pandemic, Alert Level 3 restriction period. The Alert Level 3 lockdown restrictions include a ban on travel except for essential services. All the vehicle and pedestrian counting surveys were done manually, and no video recordings were done. Counts were done in 15-minute intervals and over 3 peak periods ranging between the following times:

- 06:00 to 09:00 during the morning peak period
- 11:00 to 14:00 during the off-peak period and
- 15:00 to 18:00 during the afternoon peak period.

The tables below define the day of the week that the count was conducted at each hospital, as well as the weather on the day of the survey and the number of traffic counters that assisted in collecting the data.

Table 3-1: Manual Traffic Counts at Private Hospitals

Private Hospital	*Date of Count*	*Day of the Week*	*Counting Period*	*Weather*	*Number of Counters*
1	21/07/2020	Tuesday	06:15 - 09:00 11:00 - 14:00 15:00 - 18:00	Fine	2
2	28/07/2020	Tuesday	06:15 - 09:00 11:00 - 14:00 15:00 - 18:00	Partly Cloudy	2
3	04/08/2020	Tuesday	06:00 - 09:00 11:00 - 14:00 15:00 - 18:00	Fine	1

Table 3-2: Manual Traffic Counts at Public Hospitals

Public Hospital	*Date of Count*	*Day of the Week*	*Counting Period*	*Weather*	*Number of Counters*
Helen Joseph	06/08/2020	Thursday	06:30 - 09:00 11:00 - 14:00 15:00 - 18:00	Fine	4
Tambo Memorial	12/08/2020	Wednesday	06:00 - 09:00 11:00 - 14:00 15:00 - 18:00	Fine	2
Edenvale	13/08/2020	Thursday	06:15 - 09:00 11:00 - 14:00 15:00 - 18:00	Partly Cloudy	2

A counting sheet highlighting the method and where to record the data was distributed to the counters before counting commenced. The number of traffic counters depended on the number of operational access gates at each hospital.

The entrances to public hospitals are operated manually, one security official conducted the routine check on the vehicles and once the check is complete another security official opened the boom for a vehicle to either go in or out of the hospital. During COVID-19 pandemic, it was recommended to avoid touching surfaces in fear of the risk of viral transmission. The usual no-contact operations at public hospital access gates helped reduce the risk of infection from person to person.

Private hospitals on the other hand, make use of the electronic boom gate systems, where employees and visitors press a button on the ticket machine for a ticket and the boom system opens for the vehicle automatically. In times of COVID-19 pandemic, the parking pay systems were suspended and the boom gates for both employees and visitors were operated manually by a security official. The reason for the suspension was to minimise the viral transmission which would happen when individuals press the machine for the parking ticket. During this period, the parking was free of charge.

3.4.3 Data Collection through Automatically Recorded Information

Some of the hospital access gates have security control with the electronic capturing of vehicle movement entering and exiting the institution. The historical information was requested from the hospital management for a 12-hour period. The historical data would help compare the actual extent of COVID-19 pandemic impact on hospital traffic by comparing the traffic flows before COVID-19 pandemic and during COVID-19 pandemic.

3.4.4 Manual Parking Surveys

The number of existing parking bays characterized by the user was sourced from the hospital management. A manual count of available number of parking bays was conducted at two of the private hospitals, the remaining private hospital and public hospitals this information was provided by the hospital representatives.

On the day of the traffic count, an observation of the parking lot was made; however, no recording of already parked vehicles was made. The study will make use of the inbound and outbound vehicle trips to estimate the availability of parking spaces during the peak periods.

3.5 Data Analysis

The data analysis answers the basic questions raised in the problem statement. An overview of the data analysis method follows the procedures described under this section. The data analysis is further discussed in detail in Chapter 5.

3.5.1 Quantitative data analysis

Quantitative data were obtained from primary and secondary data discussed above in this chapter. This data analysis was based on Excel Spreadsheet and Office Word format. This data analysis focuses on numerical/quantitative data analysis. The analysis included exploring the relationship between independent variables and comparing traffic data, and how they affect each other. The information between the traffic flow and land use characteristics was linked and used to investigate the impact of the COVID-19 pandemic on the hospital traffic generation and parking demand. Tables, figures and charts were created in Microsoft Excel to reflect and compare the results analysed.

3.5.2 Qualitative data analysis

The physical data captured during the traffic counts was combined and analysed by the use of Microsoft Excel spreadsheets. The land use characteristics and other hospital information was also analysed using Excel spreadsheets. The interview, observation, and report records were used to support the findings. Under the data analysis, exploration of data has been made with descriptive statistics and graphical analysis. Qualitative data analysis was used for triangulation of the quantitative data analysis.

3.6 Data Collection Limitations

The data collection methods as discussed above have strengths and weakness discussed under this sections.

Traffic Counting at Hospital Access Gates

1. Traffic count at access gates were conducted by a team of individuals who were not professional traffic counters. They had no experience in traffic counting prior to the research data collection. It is possible that during the counting, they could record the vehicles or pedestrian incorrectly, or miss to check the changes in time period (every 15 minutes).

   To mitigate for this risk, every counter was inducted on how to conduct traffic counts before the actual count. It was also ensured that where cell-phones were

used for checking the time changes, they were fully charged a night before the traffic count. Traffic counters were provided with all the necessary paperwork, pens, camp chairs to sit on while doing counts to ensure they need not move during the counting period. The counting area was set out close to the access gate and counters were positioned in such a way that there would be no obstacles to see both pedestrians and vehicles moving through the gate.

2. The traffic counts were conducted only for a single day at each hospital and this does not account for the daily variation.

3. Traffic counts were conducted during the COVID-19 pandemic Lockdown Alert Level 3 regulations. The regulations stipulated the travel ban except when in need of essential services and for essential services providers. The visitation of hospitalised patients by family members and virtual consultation at some of the hospitals had a reduction of traffic flows at hospitals. To mitigate for this impact, traffic flows in and out of the hospital gates prior COVID-19 pandemic lockdowns were requested from the hospitals where available.

4. Traffic counting took place on six separate days, one day per hospital. Only one hospital needed four traffic counters and the remaining five hospitals needed only two traffic counters.

Conducting Interviews with Hospital Representative

1. A meeting was scheduled with representatives at each hospital. Although this was done during Lockdown Alert Level 3 with requirements for social distancing and minimising the face-to-face contact, it was clear that the hospital representative preferred to see the researcher face-to-face. The purpose of the meetings was to conduct interviews and gather background information which would rather be only known by certain people about the hospitals.

2. The interviews took place during the working hours at the time convenient to the hospital representatives. This afforded the researcher to ask more follow up questions to the questionnaire and gather furthermore information.

3.7 Ethics

The ethical matters that have been considered as part of this research project are described below.

3.7.1 Institutional Permission

The NHA (s 72(1)) requires that proposals to conduct research must undergo an independent ethics review before the research is commenced. The project proposal was submitted to the Research Ethics Committee of Stellenbosch University for approval before data collection could commence. In addition, to the ethical clearance provided by Stellenbosch University, institutional permission was required from the following institutional organizations:

- Gauteng Department of Health
- Public Hospitals that would indicate their interest to participate in the study
- Private Hospitals that would indicate their interest to participate in the study
- Private Hospital Research Committee

Once the research proposal was approved by the institution, the Department of Health Research Ethics Council and Private Hospital Ethics Committee was contacted to enquire about their regulations and procedures for conducting research studies.

3.7.2 Sourcing of Participants

Hospitals that have been identified for this research were sourced from the Gauteng Department of Health and Private Hospitals group websites. The websites also list management contact details for each hospital, which was used for initial contact.

Public Hospital

The research proposal and the institutional approval letter were submitted to the National Health Research Database (NHRD) under the Gauteng province. The NHRD in turn submit the proposal to the identified hospitals on behalf of the researcher. The hospital research committee reviews the proposal and then gives an approval in a form of a letter which is send to the researcher via the NHRD.

Private Hospitals

The private hospitals had a slightly different procedure; the researcher had to seek permission to conduct a research at each identified hospital. The hospital then gave a letter of knowledge of the research, and all the letters of knowledge from all the candidate hospitals were then submitted with the proposal to the Research Operations Committee. Once the committee has gone through the proposal, it then gave a letter of approval to conduct a research at all the identified hospitals with the ethics conditions stipulated.

3.7.3 Information Sheet and Written Consent

A letter describing the purpose of the research, the type of information required, and the method of data collection were provided to the hospital representatives. A written consent form to make participants aware that their participation is voluntary and that the information provided will be confidential was also provided to participants. The information sheets were made available in English language.

Protection of Privacy, Confidentiality, and anonymity

The research data collected by interview forms, consent forms, completed questionnaires, and traffic count sheets were collected by the researcher. This data was then scanned and kept in the researcher's laptop, which is password protected. The backup information was kept in a Dropbox folder which is also password protected. Once the information was scanned and saved electronically, the original data was shredded. Only the researcher and the supervisor had access to the electronic information shared by the participating hospitals. The questionnaire did not include personal information such as names, addresses, or the numbers of participant's representatives.

3.8 Summary

The information received from this survey will help identify the impact of COVID-19 pandemic on the hospital traffic and parking demand. The information will assist hospital management with more background information to consider in future with similar pandemics.

4. STUDY AREA

4.1 Introduction

The study area for this research project is located in the province of Gauteng in South Africa. The hospitals are based in Johannesburg and Ekurhuleni Metropolitan areas. The study involved collecting land-use characteristics such as the Gross Leasable Area (GLA) and conducting manual traffic counts at each hospital access during traffic peak periods. This chapter discusses the study area, location and attributes of the institutions included in the study.

4.2 Private Hospitals

Three private hospitals were included in this study and are discussed below. Due to ethics requirements the names of these hospitals are not provided in this report, rather the hospitals are referred to as Private Hospital 1, 2 and 3. The section discusses the locality and other characteristics such as available infrastructure.

4.2.1 Private Hospital 1

This is a private hospital located in Mayfair, Johannesburg in Gauteng. The hospital is bordered by the public roads Bartlett Road and The Corridor to the North and South, Bellona Road to the West as well as a school to the East. **Figure 4-1** below shows the locality of the hospital.

Figure 4-1: Locality of Private Hospital 1

Access

The hospital has four access gates as shown in Figure 4-1 above. Access Gate 1 is reached via Bartlett Road and is used by both visitors and employees and is controlled by a ticketed boom gate. Access Gate 2 is used by visitors and Access Gate 3 is only used by delivery vehicles. Access Gate 4 is exclusively used by the hospital employees. Access Gates 2 and 3 do not have boom gates, and only Access Gate 3 was mended by the security officers. Access Gate 4 has boom gates and employees are provided with special cards to go through the boom gates without contact.

Due to COVID-19 pandemic, only Access Gates 1, 3 and 4 were operational during the data collection period, and the majority of employees, visitors and deliveries were using Access Gate 1. Both Access Gate 1 and 4 were used by vehicles and pedestrians. The ticket system at Access Gate 1 was suspended during the COVID-19 pandemic and the boom gate was opened by the hospital security officers to minimize the virus transmission from one person to another.

Public Transport

The hospital does not have public transport facilities. Additionally, there are no public transport access point along Barlett Road or The Corridor in the vicinity of the hospital. A number of hospital employees and some patients make use of mini-bus taxis. There are no public transport embayments, taxis stop randomly to drop-off and pick-up passengers along Bartlett Road and The Corridor.

Parking

Parking for employees, patients and visitors is provided for within the hospital premises. Vehicles going through Access Gate 1 would get a ticket at the boom gate and pay for the duration spent at the hospital. The parking through Access Gate 2 is free parking and Access Gate 3 is delivery, therefore there is also no pay system. Parking through Access Gate 4 is for the employees and does not have the ticket system; however, the employees do pay a monthly fee for the parking.

Summary of Private Hospital 1 Operational Information

The summary of the information received via observation, questionnaire and personal interviews is shown in the table below.

Table 4-1: Summary of Private Hospital 1 Operational Information

Entrances	4 Access Gates (Main Entrance with boom gates ticket system) - only 3 Access Gates were operational due to COVID-19 pandemic
Hospital Area Size	24116 m^2
Number of Hospital Beds	363 beds
Number of Employees	188 employees, includes administration staff, doctors, nurses and support staff such as cleaners, drivers, etc
Parking Spaces	640 parking spaces within the hospital premises, used by employees, visitors and patients.
Number of Working Shifts	2 working shifts
Public Transport Facility	No public transport facilities within the hospital and along the local roads

4.2.2 Private Hospital 2

Private Hospital 2 is also located in Johannesburg, Gauteng. The hospital is bordered by the Nanyuki Road and Witkoppen Road to the East and South, offices to the West and residential properties to the North. **Figure 4-2** below shows the locality of the hospital.

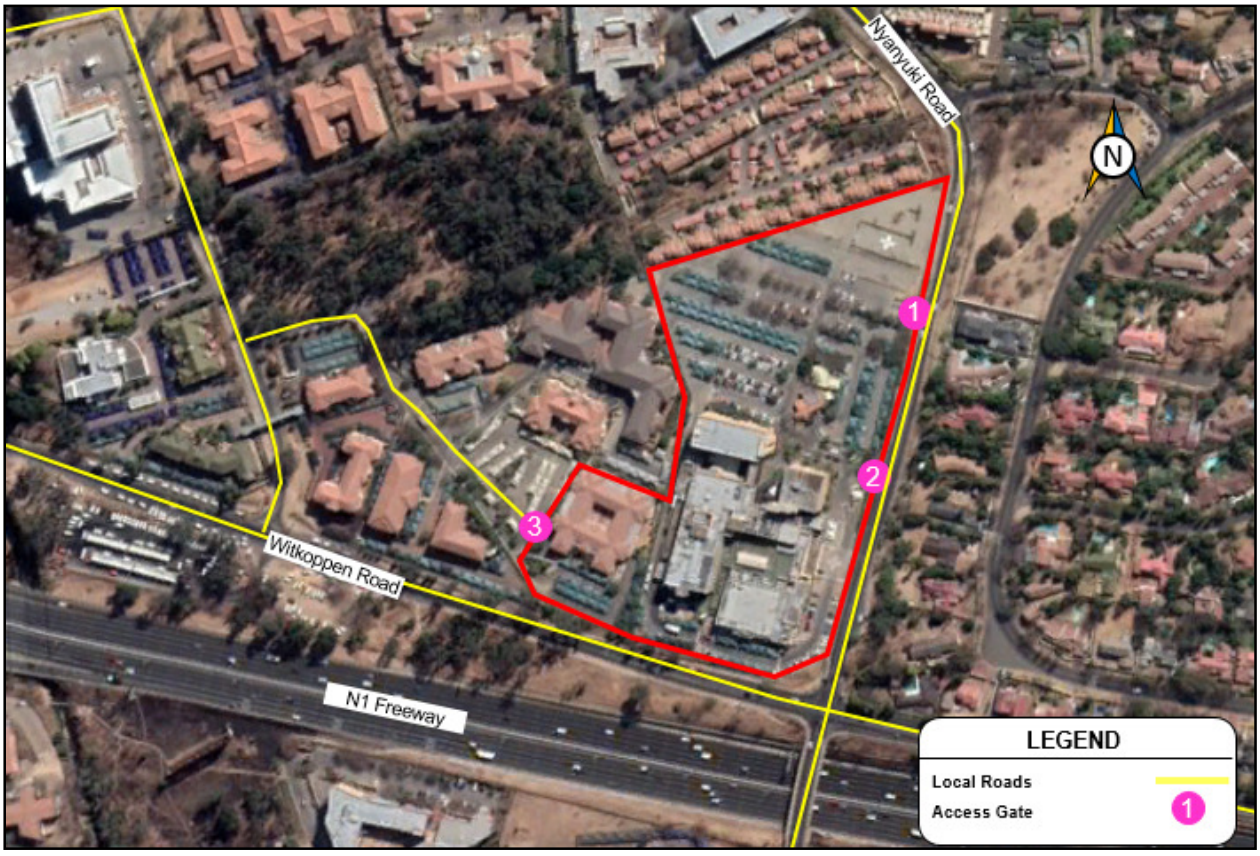


Figure 4-2: Locality of Private Hospital 2

Access

The hospital has three access gates as shown in Figure 4-2 above. Access Gate 1 is used by both visitors and employees and it is only an exit gate, gaining access to Nanyuki Road. Access Gate 2 is also used by both visitors and employees and it has both inbound and outbound lanes. Access Gate 3 is used only by vehicles and it is shared with other office buildings.

Both Access Gate 1 and Access Gate 2 make use of the ticket boom gates system which was suspended during COVID-19 pandemic. Only Access Gates 2 and Access Gate 3 were operational during the pandemic period while data collection was being conducted,

and the majority of employees, all visitors and deliveries were using Access Gate 2. Because public transport is available on Nanyuki Road, pedestrians were mainly using Access Gate 2.

Public Transport

The hospital does not have public transport facilities; however, there is a public transport embayment on the Southbound side of Nanyuki Road near the hospital Access Gate 2. Mini-bus taxis and buses often stop randomly to drop-off and pick-up passengers (mainly hospital employees) along Nanyuki Road. A taxi rank is located approximately 550 m South-East of the hospital, within walking distance.

Parking

Parking for employees, patients and visitors is provided for within the hospital premises. Vehicles going through Access Gate 2 would get a ticket at the boom gates and pay for the duration spent at the hospital. The parking through Access Gate 2 was free during the COVID-19 pandemic to minimise the viral transmission via contact. Parking through Access Gate 3 is exclusive to the hospital employees and the employees pay a monthly fee for the parking.

Summary of Private Hospital 2 Operational Information

The summary of the information received via observation, questionnaires and personal interviews is shown in the table below.

Table 4-2: Summary of Private Hospital 2 Operational Information

Entrances	3 Access Gates - only 2 Access Gates were operational due to COVID-19 pandemic
Hospital Area Size	19 229 m^2
Number of Hospital Beds	279 beds
Number of Employees	596 employees, includes administration staff, doctors, nurses and support staff such as cleaners, drivers, etc
Parking Spaces	1700 parking spaces within the hospital premises, used by employees, visitors and patients.
Number of Working Shifts	2 working shifts
Public Transport Facility	No public transport facilities within the hospital, only one embayment on the Southbound of Nanyuki Road

4.2.3 Private Hospital 3

Private Hospital 3 is located in Johannesburg, Gauteng. The hospital is bordered by Maxwell Drive to the North-West, Jukskei View Drive to the South, Magwa Cresent to the East and offices to the North. **Figure 4-3** below shows the locality of the hospital.

Figure 4-3: Locality of Private Hospital 3

Access

The hospital has two access gates, both from Magwa Crescent as shown in Figure 4-3 above. Access Gate 1 is used by visitors and employees. Access Gate 2 is used only by employees and delivery vehicles. Access Gate 1 makes use of the ticket boom gates system which was suspended during COVID-19 pandemic. Both gates were operational during the data collection, and majority of employees who make use of public transport were using Access Gate 2.

Public Transport

The hospital does not have public transport facilities within the property. Public transport embayments are available along all the roads surrounding the hospital. Although formal public transport embayments are provided for, mini-bus taxis often stop randomly along Magwa Crescent and Jukskei View Road to drop-off and pick-up passengers (mainly hospital employees).

Parking

Parking for employees, patients and visitors is provided for within the hospital premises. Vehicles going through Access Gate 1 would get a ticket at the boom gate and pay for the duration spent at the hospital. The entrance through Access Gate 2 is for delivery and has no pay system. Employees pay a monthly fee for parking and therefore do not use the ticket system.

Summary of Private Hospital 3 Operational Information

The summary of the information received via observation, questionnaire and personal interviews is shown in the table below.

Table 4-3: Summary of Private Hospital 3 Operational Information

Entrances	2 Access Gates and they were both operation during COVID-19 pandemic
Hospital Area Size	22 647 m^2
Number of Hospital Beds	200 beds
Number of Employees	417 employees, includes administration staff, doctors, nurses and support staff such as cleaners, drivers, etc
Parking Spaces	630 parking spaces within the hospital premises, used by employees, visitors and patients.
Number of Working Shifts	2 working shifts
Public Transport Facility	No public transport facilities within the hospital, embayments are available on all the local road network

4.3 Public Hospitals

Three public hospitals were investigated in this research project. This section discusses the locality and other characteristics such as available infrastructure of the public hospitals.

4.3.1 Helen Joseph Hospital

Helen Joseph hospital is one of the 3 Tertiary Education Teaching Hospitals in Gauteng. The hospital is situated in Auckland Park suburbs in the Johannesburg metro. It is surrounded by Perth Road to the North, Akademie Road to the East, Whitehall Street to the West and Plunkett Avenue to the South. University of Johannesburg, Auckland Park campus is located to the East of the hospital. **Figure 4-4** below shows the locality of the hospital. The hospital is linked to the Wits Medical School and Ann Latsky Nursing school for training professionals.

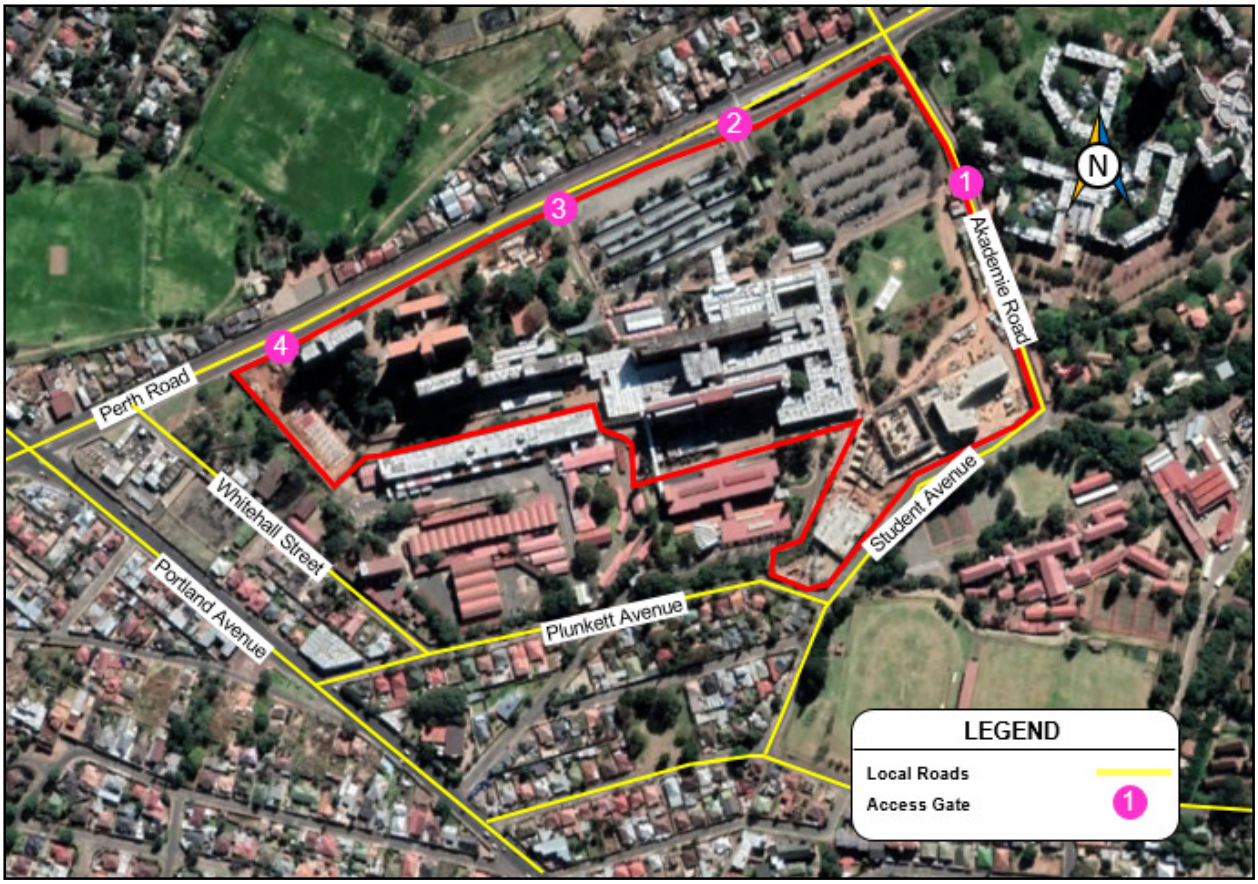


Figure 4-4: Locality of Helen Joseph Hospital

Access

The hospital has four access gates as shown in Figure 4-4. Access Gate 1 is used as an exit only gate however; pedestrians can enter and exit the hospital through this gate. Access Gate 2 is the main gate for both vehicles and pedestrians. Access Gates 3 and 4 are mainly used by hospital employees.

There are security boom gates at Access Gate 1 and Access Gate 2 which are manually opened by security officers. Access Gate 3 and Access Gate 4 have sliding gates which are also manually opened by the security officer.

Public Transport

There is provision for a taxi holding area along Perth Road between Access Gates 2 and Access Gates 3. Rea-Vaya Bus Rapid Transit is operational on Perth Road and there is a bus station along Perth Road East of Access Gate 2. Wits University bus transporting student trainees is allowed to drive into the hospital premises. However, taxis still stop randomly along Perth Road to drop off-and pic-up passengers.

Parking

Parking for employees, patients and visitors is provided for within the hospital premises. Visitors' parking has been provided separate to employees parking. Employees pay a monthly fee for parking and visitors' parking is free of charge.

Summary of Helen Joseph Hospital Operational Information

The summary of the information received via observation, questionnaire and personal interviews is shown in the table below.

Table 4-4: Summary of Helen Joseph Hospital Operational Information

Entrances	4 Access Gates - all were operational during the day, however only Gate 2 and 4 were operational for 24 hrs
Hospital Area Size	50 000 m^2
Number of Hospital Beds	616 beds
Number of Employees	1 811 employees, includes administration staff, doctors, nurses and support staff such as cleaners, drivers, etc
Parking Spaces	365 parking spaces within the hospital premises, used by employees, visitors and patients.
Number of Working Shifts	2 working shifts
Public Transport Facility	A public transport facility and Rea-Vaya BRT bus stop exists in-front of the hospital premises, along Perth Road

4.3.2 Tambo Memorial Hospital

Tambo Memorial hospital is a regional hospital in Ekurhuleni area in Gauteng province. It is situated in Boksburg in Ekurhuleni metro. The Hospital is surrounded by Offices to the East and North, Hospital Road to the West and Railway Street and the Railway Line to the South. Boksburg railway station is located about 400 m South-West of the hospital. **Figure 4-5** below shows the locality of Tambo Memorial Hospital.

Figure 4-5: Locality of Tambo Memorial Hospital

Access

The hospital has two access gates as shown above. Access Gate 1 is the main access for both vehicles and pedestrians from Railway Street. This gate does not have booms; the security officers make use of traffic cones to control the incoming and exiting traffic. The security officer searches all the vehicles entering and exiting the hospital premises. Access Gate 2 is the pedestrian access gate through a turnstile which is linked to the parking provided in-front of the hospital. Both gates were operational during the COVID-19 pandemic.

Public Transport

There is provision for formal mini-bus taxi stopping facilities along Railway Street in-front of the hospital property. There are no public transport embayments on any of the local road network surrounding the hospital, buses and taxis stop randomly to drop-off and

pick-up passengers. Wits University bus transporting student trainees is allowed to drive into the hospital premises.

Parking

Parking for employees, patients and visitors is provided for within the hospital premises. Another parking is provided adjacent to the hospital via Access Gate 2, however, this facility is not owned by the hospital.

Summary of Tambo Memorial Hospital Operational Information

The summary of the information received via observation, questionnaire and personal interviews is shown in the table below.

Table 4-5: Summary of Tambo Memorial Hospital Operational Information

Entrances	2 Access Gates - and they were both operational during the surveys. Access Gate 1 remains operational for 24 hours and Access Gate 2 is opened between 06:00 AM and 18:00 PM
Hospital Area Size	110 300 m^2
Number of Hospital Beds	604 beds
Number of Employees	1 490 employees, includes administration staff, doctors, nurses and support staff such as cleaners, drivers, etc
Parking Spaces	378 parking spaces within the hospital premises, used by employees, visitors and patients.
Number of Working Shifts	2 working shifts
Public Transport Facility	A taxi facility exists in-front of the hospital property

4.3.3 Edenvale Hospital

Edenvale hospital is a regional hospital in Ekurhuleni area in Gauteng province. It is situated in Edenvale along Modderfontein Road in Ekurhuleni metro. The hospital is bounded by R25 (Modderfontein Road) to the North, Residential properties to the West. The N3 National Freeway runs about 450 m to the East and Jukskei River runs to the South of the hospital. **Figure 4-6** below shows the locality of the hospital.

Figure 4-6: Locality of Edenvale Hospital

Access

The hospital has two access gates as shown above. Access Gate 1 is the main access for both vehicles and pedestrians via Modderfontein Road. This access has security boom gates and the security officers search vehicles entering and exiting the hospital, the boom gates are opened by another officer after the vehicle search has been complete. A pedestrian turnstile gate is also provided at Access Gate 1. Access Gate 2 is the pedestrian access gate and it also has a turnstile gate.

Public Transport

The hospital has made a provision for formal holding area at Access Gate 2; however, this area is rarely used by the taxis. Most of the passengers get dropped in-front of the main gate. There are no public transport embayments along Modderfontein Road. Buses and taxis stop randomly in-front of Access Gate 2, along Modderfontein Road to drop-off

and pick-up passengers. A bus transporting training nurses is allowed to drive into the hospital premises.

Parking

Parking for employees, patients and visitors is provided for within the hospital premises. Visitors' parking has been provided separate to employees parking. Employees pay a monthly fee for parking and visitors' parking is free of charge.

Summary of Edenvale Hospital Operational Information

The summary of the information received via observation, questionnaire and personal interviews is shown in the table below.

Table 4-6: Summary of Edenvale Hospital Operational Information

Entrances	2 Access Gatess and they were both operation during COVID-19 pandemic
Hospital Area Size	161 200 m^2
Number of Hospital Beds	287 beds
Number of Employees	849 employees, includes administration staff, doctors, nurses and support staff such as cleaners, drivers, etc
Parking Spaces	264 parking spaces within the hospital premises, used by employees, visitors and patients.
Number of Working Shifts	2 working shifts
Public Transport Facility	A taxi facility exists adjacent to the hospital

4.4 Summary

The researcher only received information from three private hospitals and three public hospitals. One of the private hospitals pulled out of the research during the data collection and one of the public hospitals never gave permission for the study at their hospital. Therefore, the research focuses on six hospitals as described above.

5. RESULTS AND DISCUSSIONS

5.1 Introduction

The aim of this chapter is to present the results of the data obtained at hospital institutions mentioned under the study area in Chapter 4 above. As mentioned in the methodology the data collection includes modal split between vehicles and pedestrians, and travel direction per peak hour (Inbound and outbound). This chapter discusses the following results for each of the hospitals:

- Peak period traffic flow during the COVID-19 pandemic,
- Traffic flow changes at some of the hospital where pre-COVID-19 pandemic data was available,
- Pedestrian movements,
- Trip Generation Rates, and
- Parking demand at each hospital based on the traffic flow data collected.

The information results are from six hospitals in Johannesburg and Ekurhuleni metros in Gauteng province.

5.2 Google Earth Imagery at the Participating Hospitals

A reduction in midday traffic at hospitals was expected between 09:00 AM and 15:00 PM, this is the period usually patients visit the doctors' room or hospitalised patients are visited by family members. Due to COVID-19 pandemic restrictions it was expected that there will be fewer vehicles on the hospital parking area. Google Earth satellite images were used to evaluate the impact of COVID-19 on hospital traffic by comparing images prior the pandemic and during the pandemic.

5.2.1 Imagery information at Private Hospital 1

The satellite Google Earth images at Private Hospital 1 in Johannesburg shows the vehicles at visitors parking area on different dates. **Figure 5-1** below shows the visitors parking area on Friday 30 August 2019 which was before the pandemic. The picture shows that the parking area was almost full. The undercover parking is for hospital employees and the uncovered parking is for visitors and patients.

Figure 5-1: Google Earth picture at Private Hospital 1 – Tuesday 20/08/2019

Figure 5-2 below shows the same parking area at Private Hospital 1 on Monday 20 April 2020 which was during the COVID-19 pandemic, Lockdown Alert Level 5. The figure shows fewer vehicles at the visitors parking area which can be attributed to the Lockdown Alert Level 5 restrictions and strict hospital regulations.

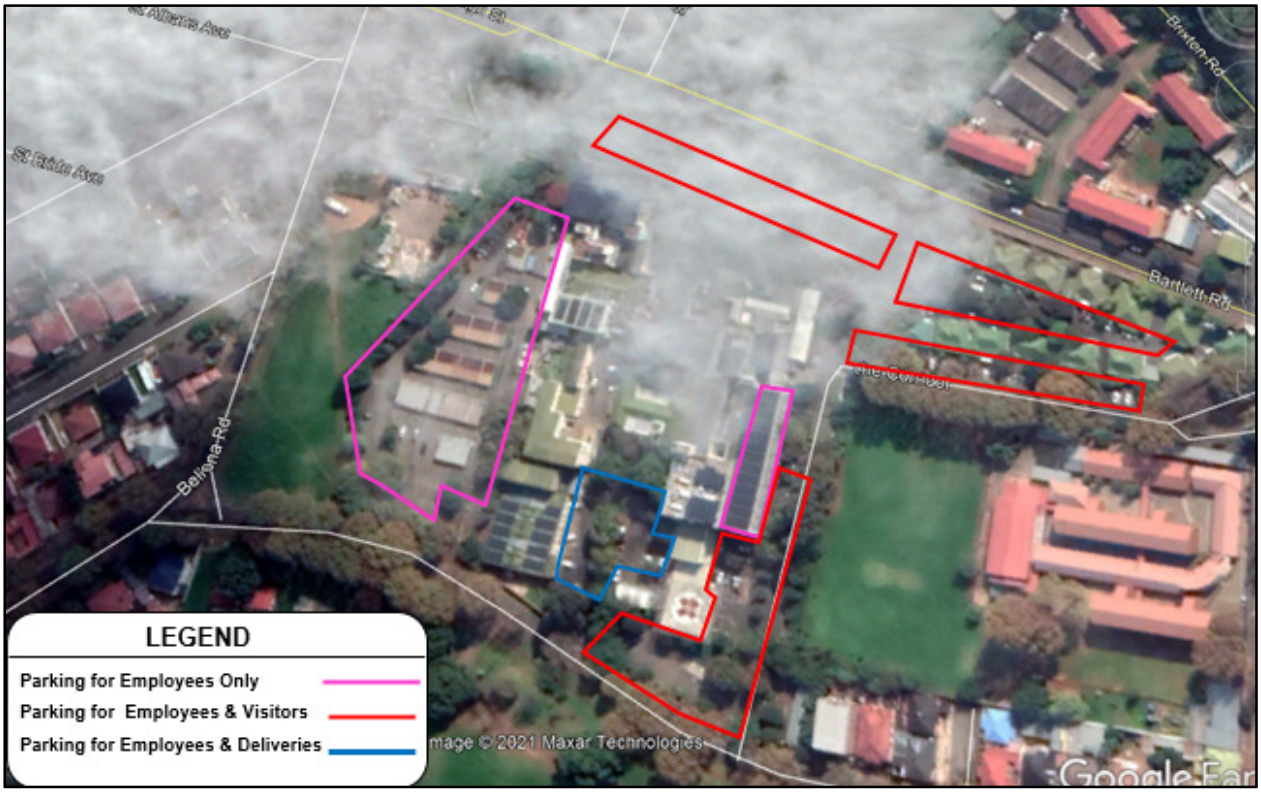


Figure 5-2: Google Earth picture at Private Hospital – Tuesday 20/04/2020

5.2.2 Imagery information at Private Hospital 2

The satellite Google Earth images at Private Hospital 2 in Johannesburg shows the vehicles at visitors parking area on different dates. **Figure 5-3** below shows more visitors' vehicles parked on the parking area on Friday 30 August 2019 which was before the pandemic. The picture shows that the parking area was almost full. The undercover parking is for hospital employees and the uncovered parking is for visitors and patients.

Figure 5-3: Google Earth picture at Private Hospital 2 – Friday 30/09/2019

Figure 5-4 below shows the same parking area at Private Hospital 2 on Friday 10 July 2020 which was during the COVID-19 pandemic, Lockdown Alert Level 3. The figure shows fewer visitors vehicles parked at the parking area which can be attributed to the Lockdown Alert Level 3 restrictions and strict hospital regulations. The figure also shows tents erected on the parking area which were used for patient screening for both visitors and employees before they could proceed into the hospital building.

Figure 5-4: Google Earth picture at Private Hospital 2 – Friday 10/07/2020

5.2.3 Imagery information at Private Hospital 3

The satellite Google Earth images at Private Hospital 3 in Johannesburg shows the vehicles at visitors parking area on different dates. **Figure 5-5** below shows the visitors parking area on Monday 22 July 2019 which was before the pandemic. The picture shows that the parking area was almost full. The undercover parking is for hospital employees and the uncovered parking (visible vehicles) is for visitors and patients.

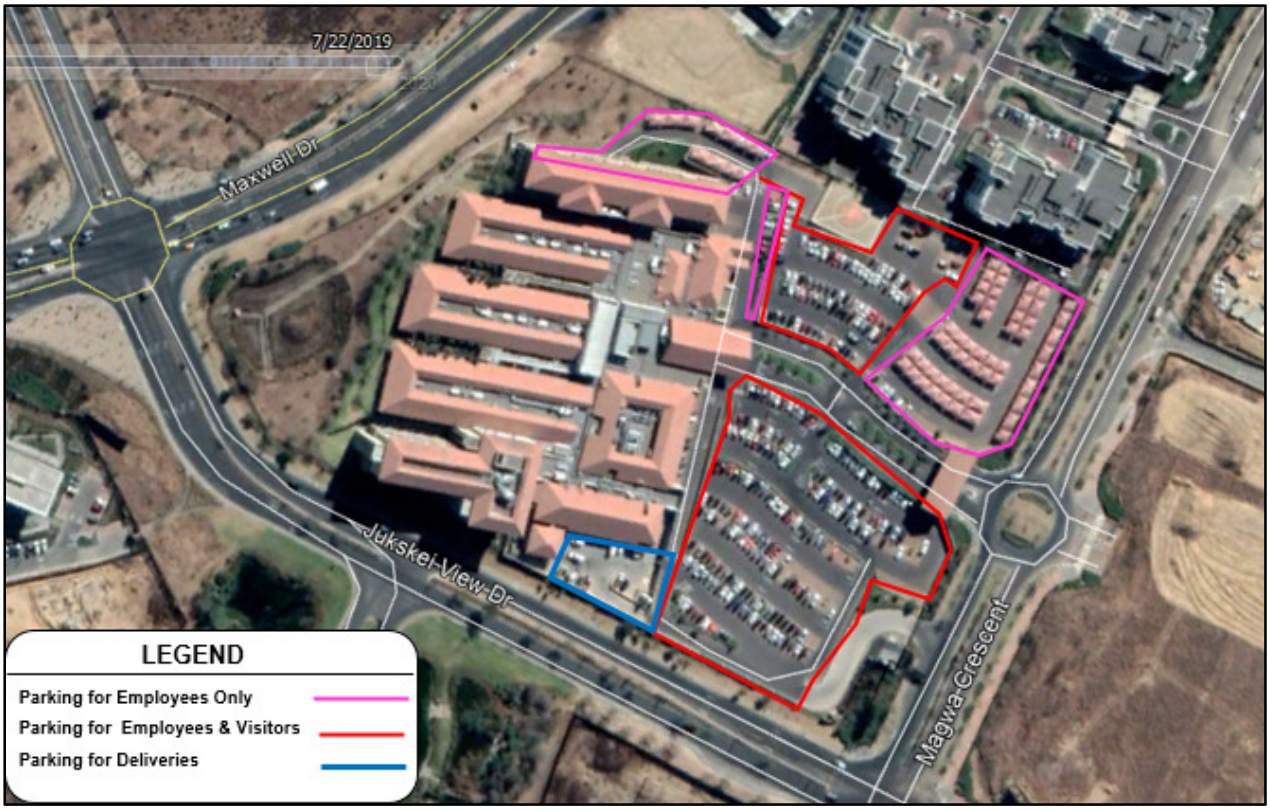


Figure 5-5: Google Earth picture at Private Hospital 3 – Monday 22/07/2019

Figure 5-6 below shows the same parking area at Private Hospital 3 on Monday 20 April 2020 which was during the COVID-19 pandemic, Lockdown Alert Level 5. The figure shows fewer vehicles at the visitors parking area which can be attributed to the Lockdown Alert Level 5 restrictions and strict hospital regulations. The tent for screening was erected in-front of the hospital entrance, on pick-up and drop-off area.

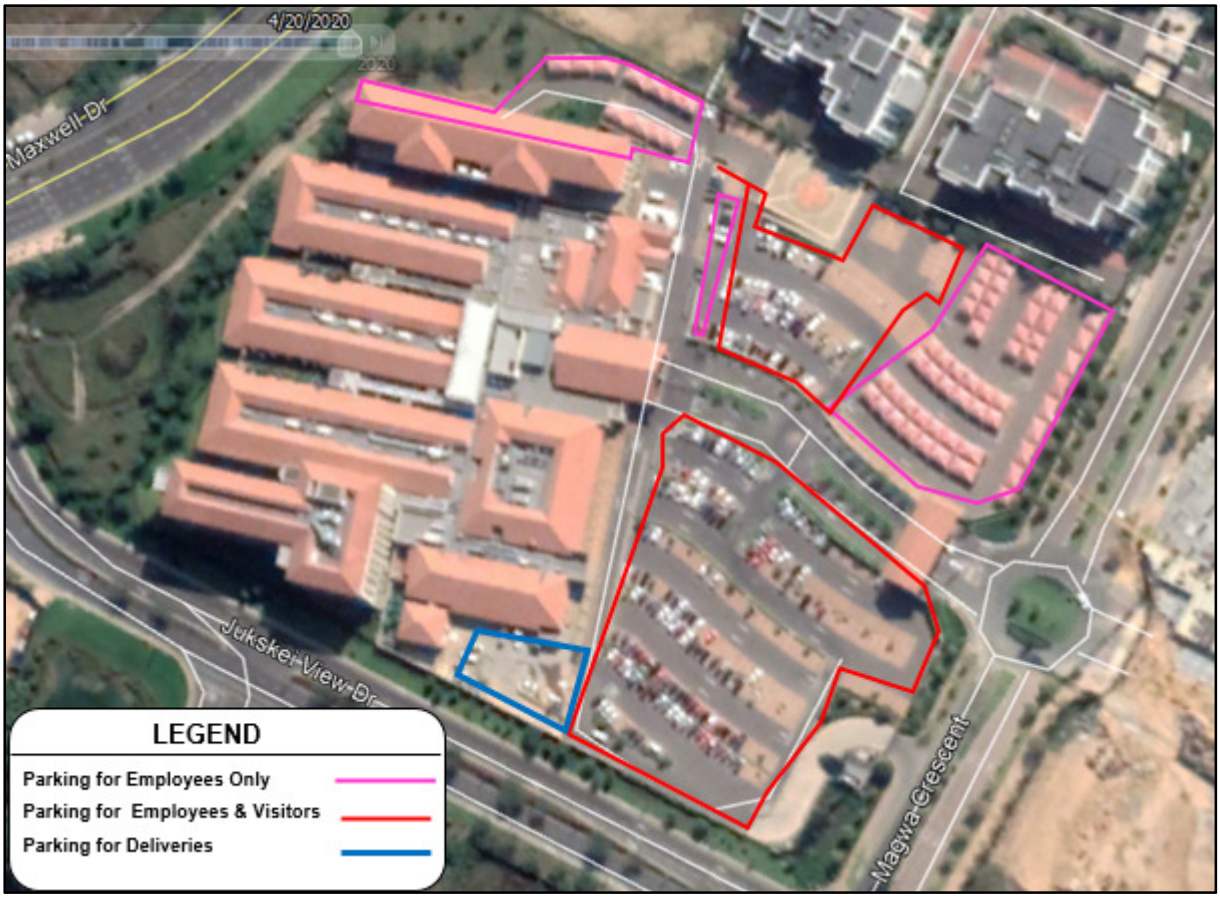


Figure 5-6: Google Earth picture at Private Hospital 3 – Monday 20/04/2020

5.2.4 Imagery Information at Helen Joseph Hospital

The satellite Google Earth images at Helen Joseph Hospital in Johannesburg shows the vehicles at visitors parking area and taxi holding area on different dates. **Figure 5-7** below shows the visitors parking area on Tuesday 20 August 2019 which was before the pandemic. The picture shows that the parking area was almost full and there were more than half parking spaces occupied at the taxi holding area.

Figure 5-7: Google Earth picture at Helen Joseph Hospital – Tuesday 20/08/2019

Figure 5-8 below shows the same parking area at Helen Joseph Hospital on Thursday 20 August 2020 which was during the COVID-19 pandemic, Lockdown Alert Level 2. The figure shows fewer vehicles at the visitors parking area and even the taxi holding area which can be attributed to the Lockdown Alert Level 2 restrictions and strict hospital regulations. The figure also shows tents erected on the parking area which were used for patient screening before they could proceed into the hospital building.

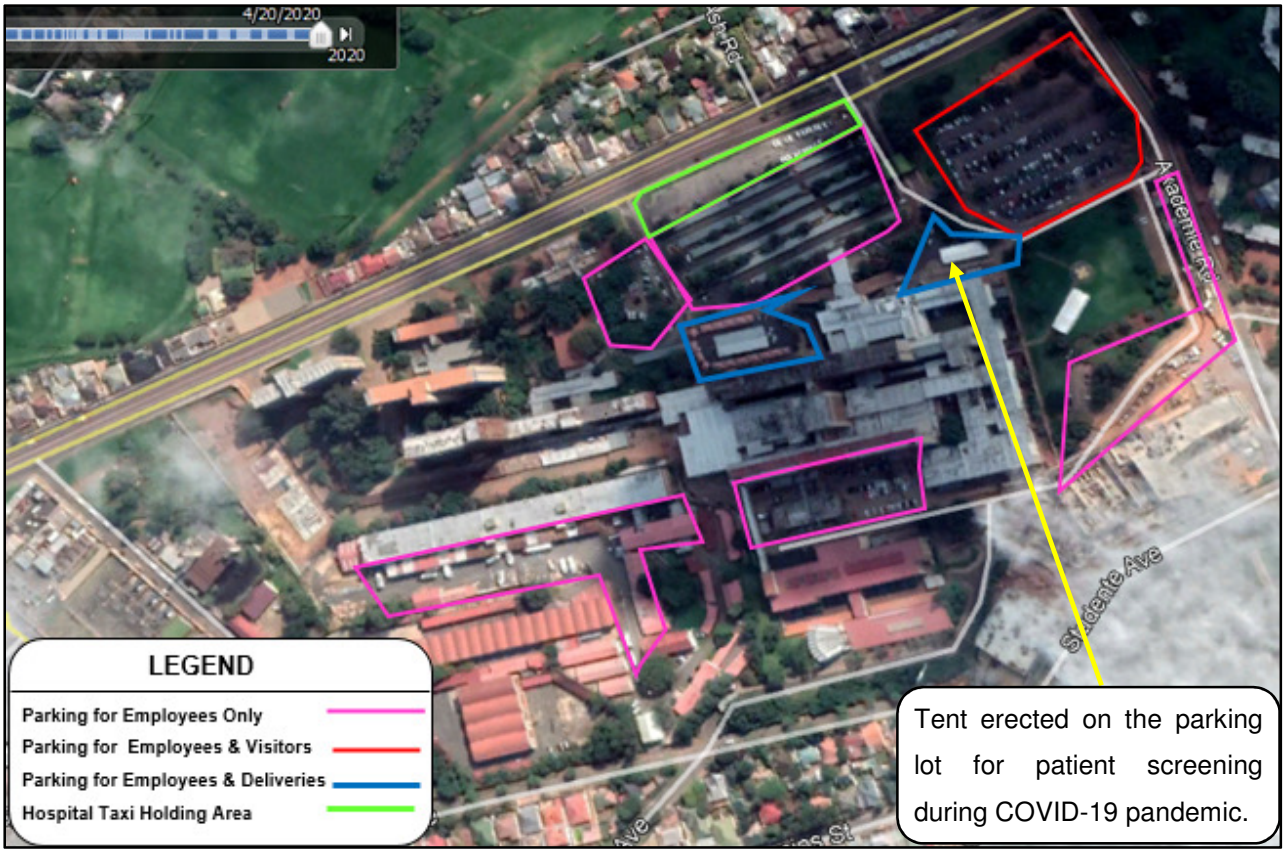


Figure 5-8: Google Earth picture at Helen Joseph Hospital – Monday 20/04/2020

5.2.5 Imagery Information at Tambo Memorial Hospital

The satellite Google Earth images at Tambo Memorial Hospital in Ekurhuleni shows the vehicles at visitors parking area and within the hospital premises. Parking within the hospital is shared between hospital visitors, patients and hospital employees. **Figure 5-9** below shows the visitors parking area on Tuesday 20 August 2019 which was pre-COVID-19 pandemic. The figure shows that the parking area was almost full and there were a high number of taxis parked at the taxi holding area.

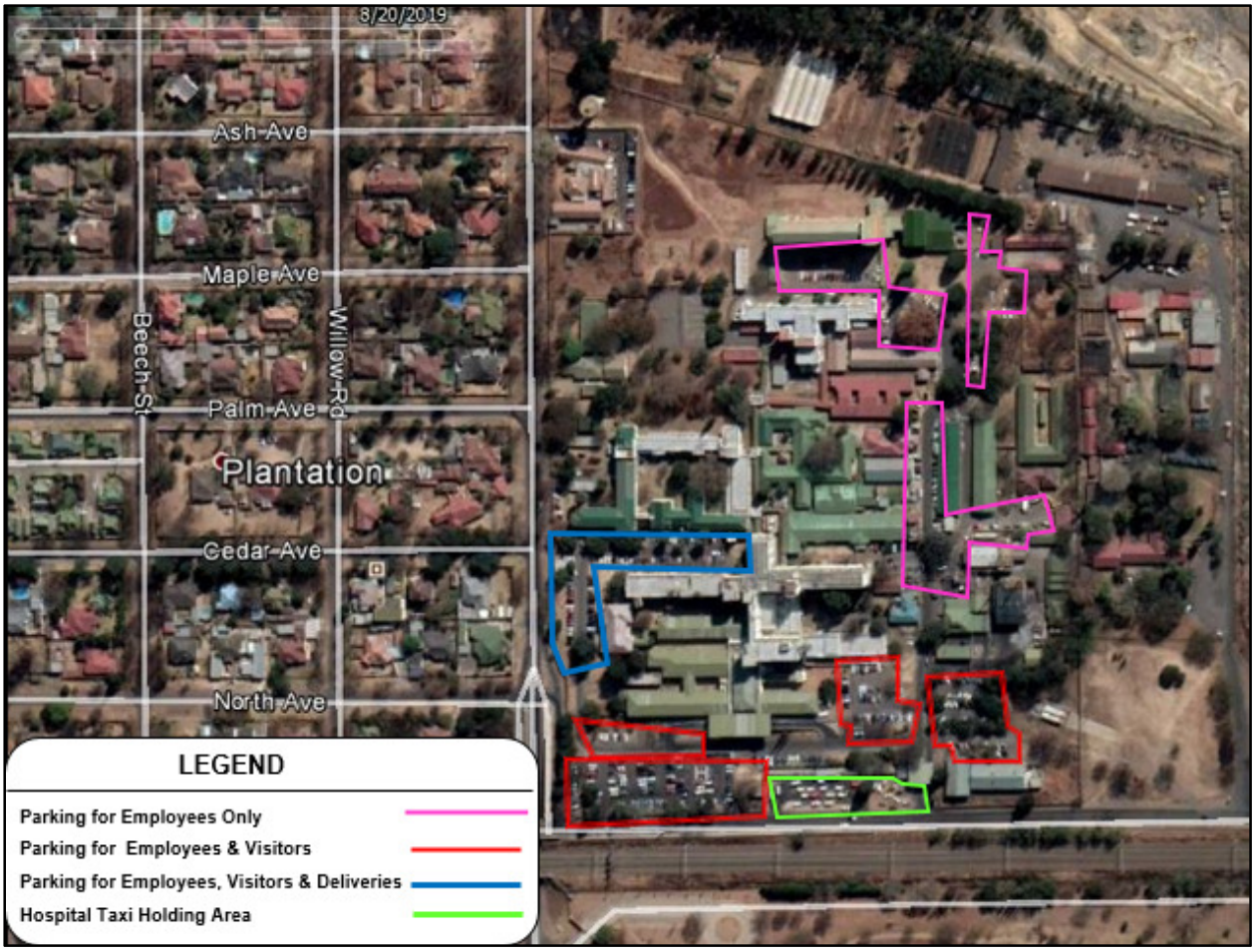


Figure 5-9: Google Earth picture at Tambo Memorial Hospital – Tuesday 20/08/2019

Figure 5-10 below shows the same parking area at Tambo Memorial Hospital on Monday 20 April 2020 which was during the COVID-19 pandemic, Lockdown Alert Level 5. The figure shows relatively less vehicles at the visitors' parking area and even the taxi holding area which can be attributed to the Lockdown Alert Level 5 restrictions and strict hospital regulations.

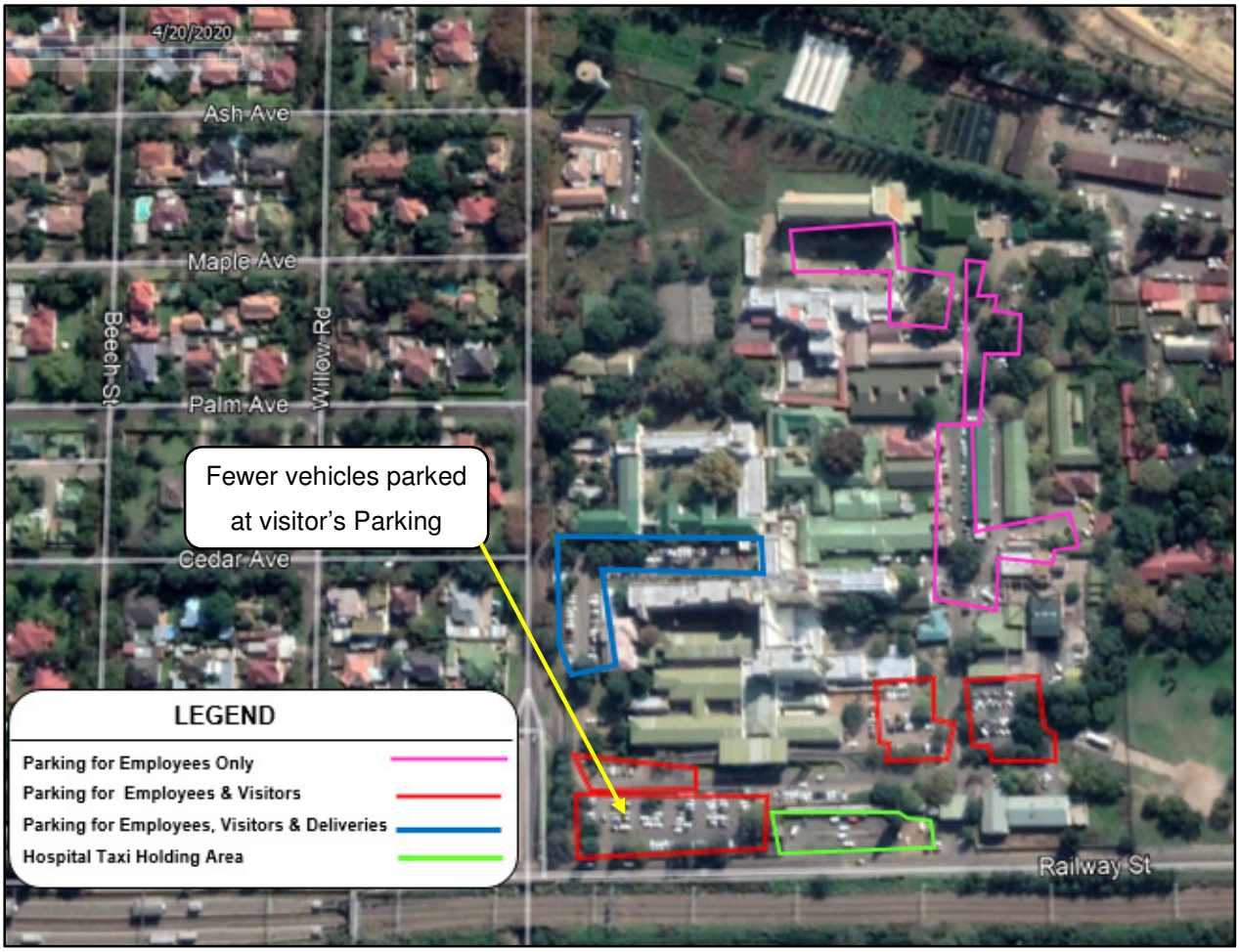


Figure 5-10: Google Earth picture at Tambo Memorial Hospital – Monday 20/04/2020

5.2.6 Imagery Information at Edenvale Hospital

The satellite Google Earth images at Edenvale Hospital in Ekurhuleni shows the vehicles at visitors parking area and within the hospital premises. Parking for visitors within the hospital is provided for separate to hospital employees' parking. **Figure 5-11** below shows the visitors parking area on Monday 02 May 2019 which was before COVID-19 pandemic. The figure shows that the parking area was almost full and there were a high number of taxis parked along Modderfontein Road, outside of the hospital gate.

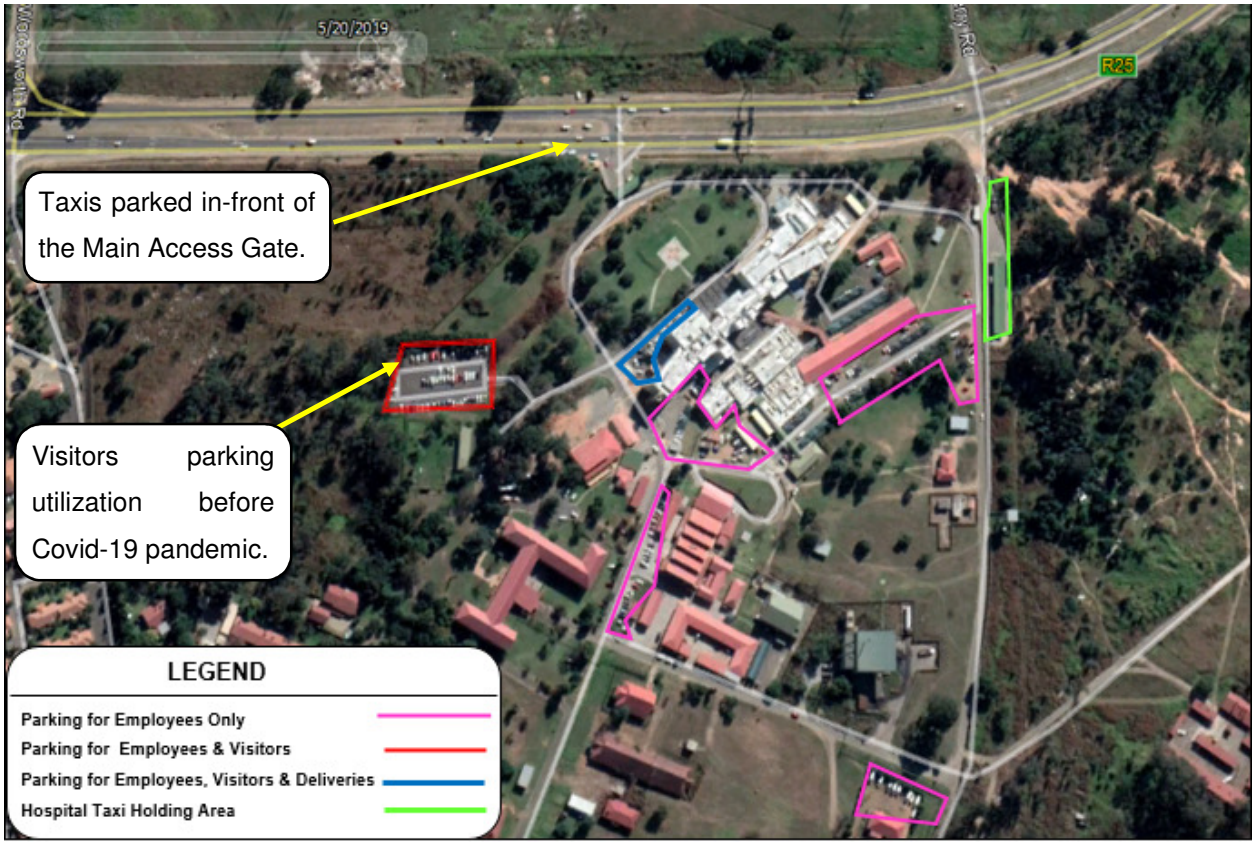


Figure 5-11: Google Earth picture at Edenvale Hospital – Monday 20/05/2019

Figure 5-12 below shows the same parking area at Edenvale Hospital on Monday 20 April 2020 which was during the COVID-19 pandemic, Lockdown Alert Level 5. The figure shows relatively less vehicles at the visitors parking area and even the taxi holding area which can be attributed to the Lockdown Alert Level 5 restrictions and strict hospital regulations.

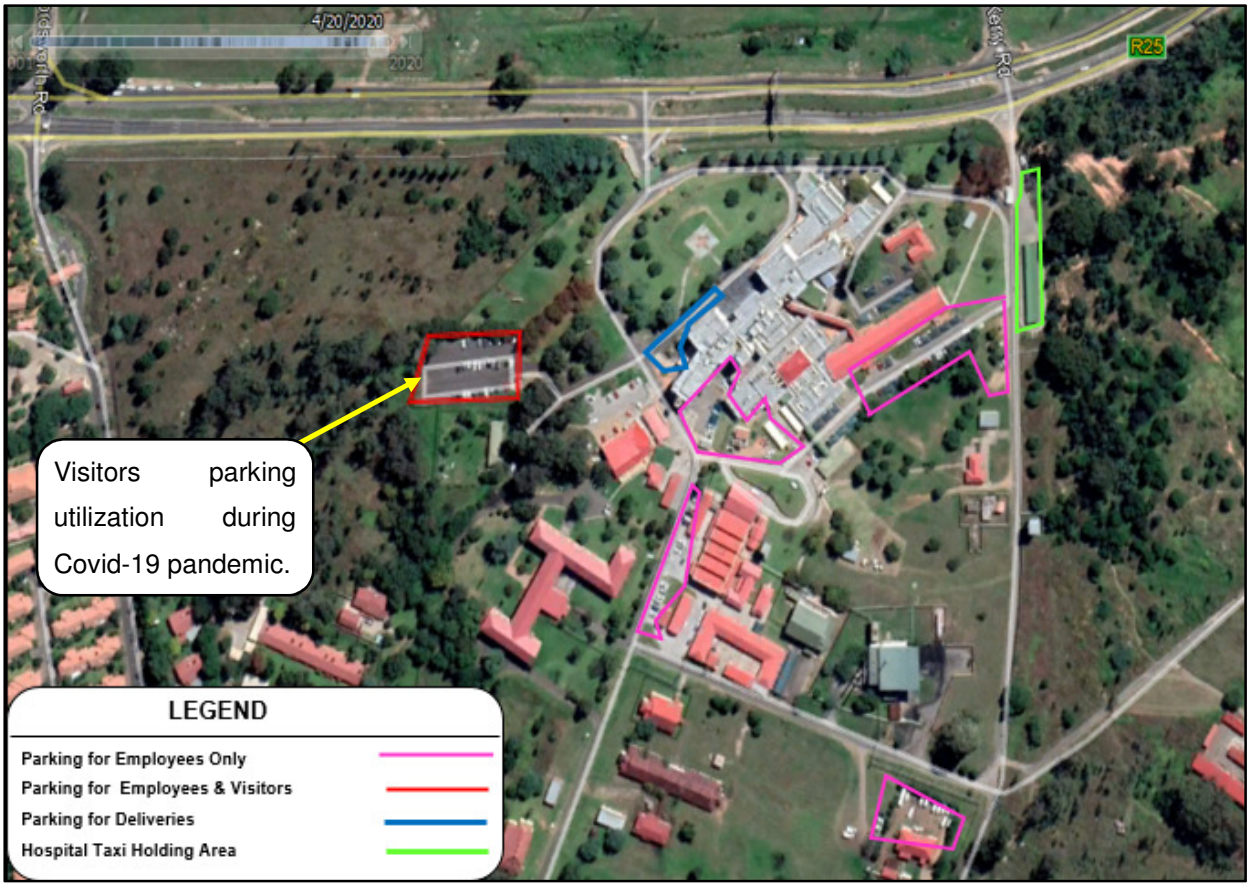


Figure 5-12: Google Earth picture at Edenvale Hospital – Monday 20/04/2020

5.3 Traffic Flow – Private Hospitals

The traffic flow patterns during COVID-19 pandemic at each of the hospitals will be compared in this section. The results obtained were put through statistical analysis and are presented below.

5.3.1 Traffic Flow Volumes – During COVID-19 Pandemic

Traffic flow volumes at private hospitals are shown in **Figure 5-1, Figure 5-2 and Figure 5-3** below. The figures show the 15-minutes directional traffic as well as the total traffic flow for both inbound and outbound traffic. The time period where counts were not conducted are reflected with no data on the figures. No distinction was made between the employees and hospital visitors (for both vehicles and pedestrians) during the data capturing. The data reflects a total of what was captured at all operational gates at each hospital.

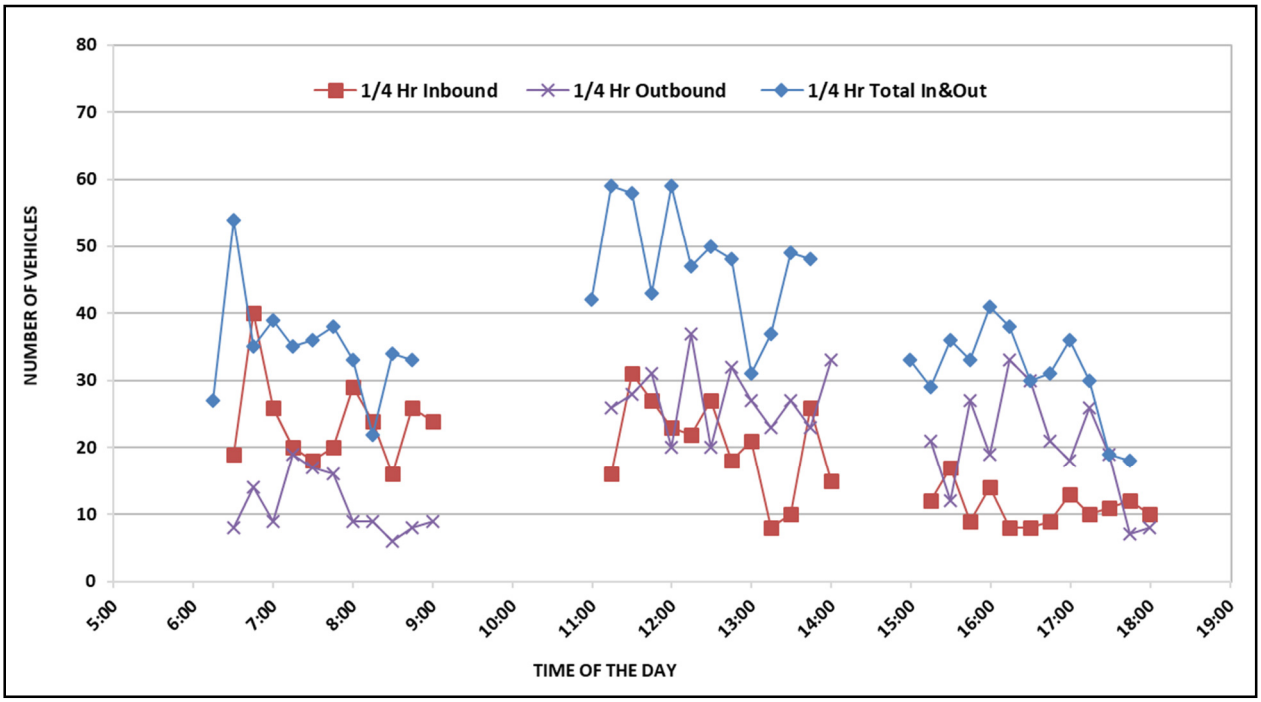


Figure 5-13: Traffic Flows Patterns (15 Min) – Private Hospital 1

The directional split during the morning peak period shows higher inbound movement compared to the outbound and vice versa during the afternoon peak period. Only at Private Hospital 2, the inbound traffic still shows higher volumes in the afternoon period.

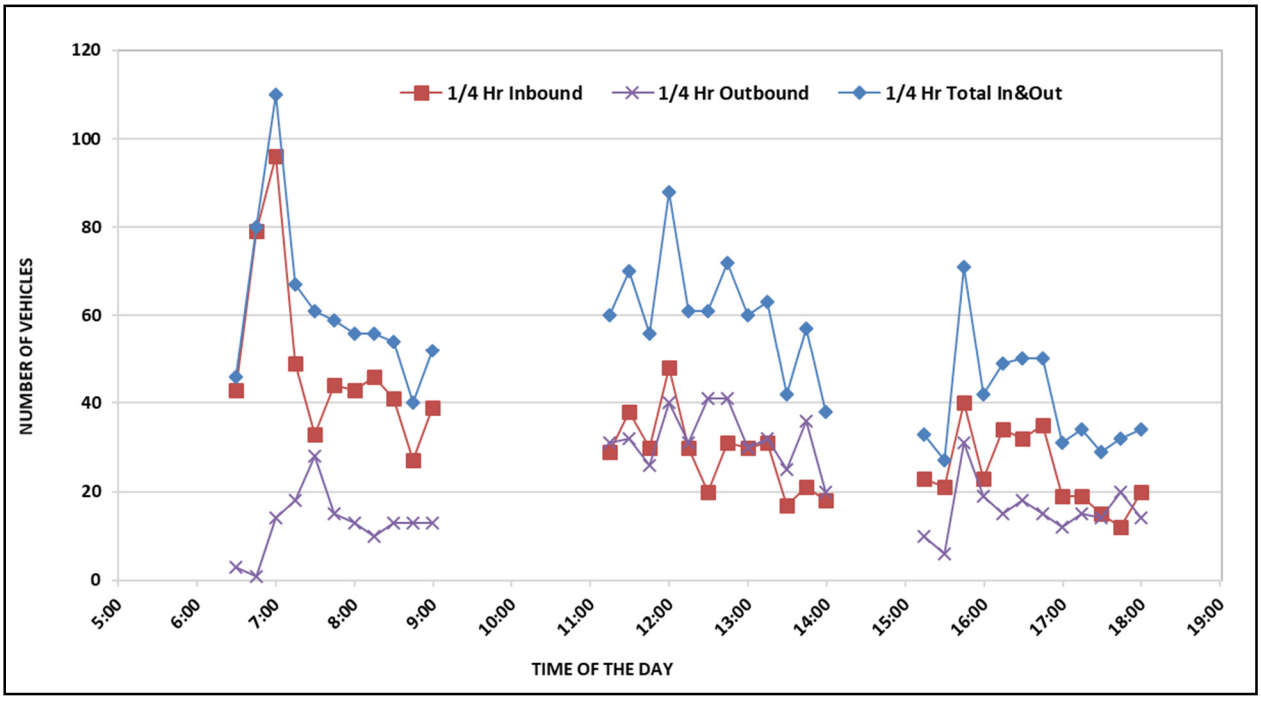


Figure 5-14: Traffic Flows Patterns (15 Min) – Private Hospital 2

The 15-minutes traffic flow during the midday shows a relatively balanced traffic flows both inbound and outbound traffic at all the private hospitals. The midday peak hour traffic volumes were however less than the morning and afternoon peak hour volumes.

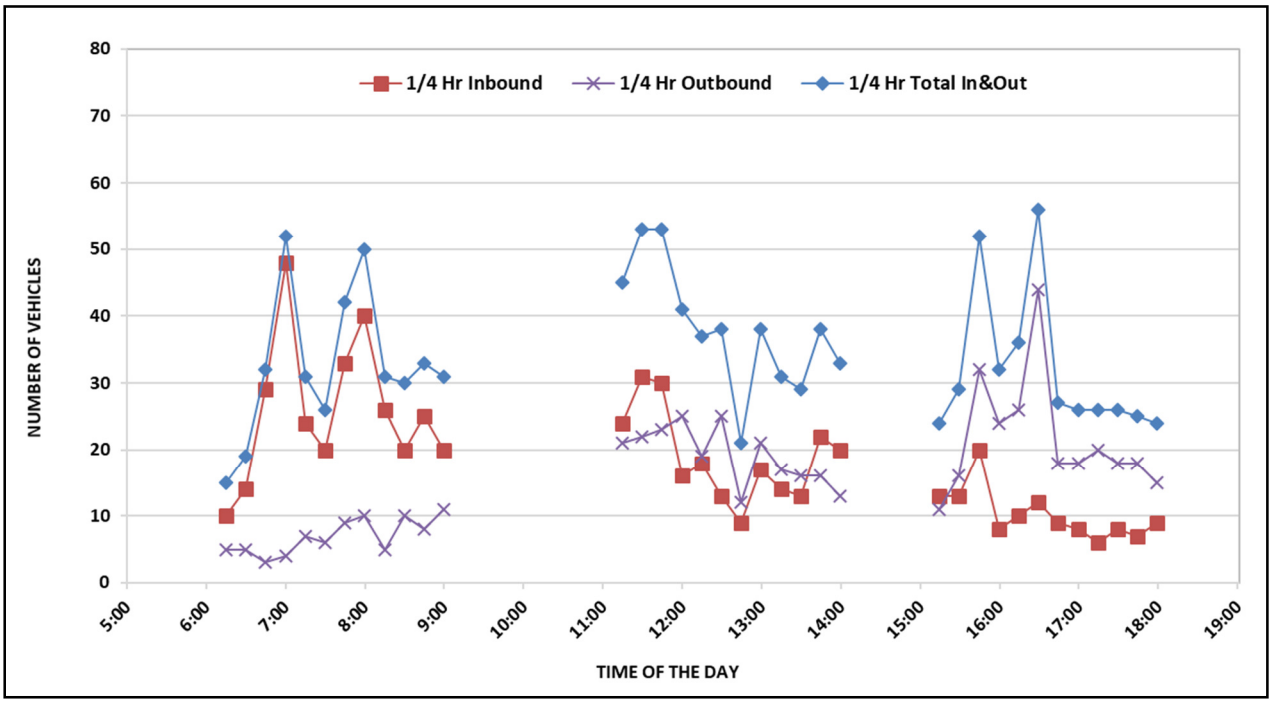


Figure 5-15: Traffic Flows Patterns (15 Min) – Private Hospital 3

The morning and midday peak hours occurred at different times for the Private Hospitals and the afternoon peak hour occurred at similar time period at all the hospitals. Refer to **Table 5-1** below for the peak hour volumes and peak hour periods.

Table 5-1: Peak Hour Volumes at Private Hospitals

Hospital (Private)	*Peak Period*	*Peak Hour*	*Peak Hour Volumes*		
			In	*Out*	*Total*
Private Hospital 1	AM	06:15 - 07:15	104	59	**163**
	MIDDAY	11:15 - 12:15	103	116	**219**
	PM	15:30 - 16:30	39	109	**148**
Private Hospital 2	AM	06:30 - 07:30	257	61	**318**
	MIDDAY	11:45 - 12:45	129	153	**282**
	PM	15:30 - 16:30	129	83	**212**
Private Hospital 3	AM	06:45 - 07:45	125	39	**151**
	MIDDAY	11:00 - 12:00	101	91	**192**
	PM	15:30 - 16:30	50	126	**176**

5.3.2 Traffic Flow Volumes – Before COVID-19 Pandemic

The traffic flow patterns before COVID-19 were sourced from the hospital security system records. The data was obtained from two private hospitals, Private Hospital 2 and Private Hospital 3 records. The hourly traffic flow patterns were requested for Tuesday 18 to Thursday 20 February 2020 which was normal on weekdays. **Figure 5-16** below shows hourly results from Private Hospital 2 and **Figure 5-17** shows the 15-minute traffic flow from Private Hospital 3.

The results demonstrate that the morning and afternoon peak traffic flow patterns were similar; the inbound traffic flow is higher during the morning peak compared to the afternoon. Both graphs also highlight that the traffic flows pre COVID-19 pandemic were higher during the midday peak period compared to the morning and afternoon peak periods at both hospitals. The traffic during the midday comprise of patients and visitors (usually families visiting patients). However, during COVID-19 pandemic visitors were not allowed except for emergency cases.

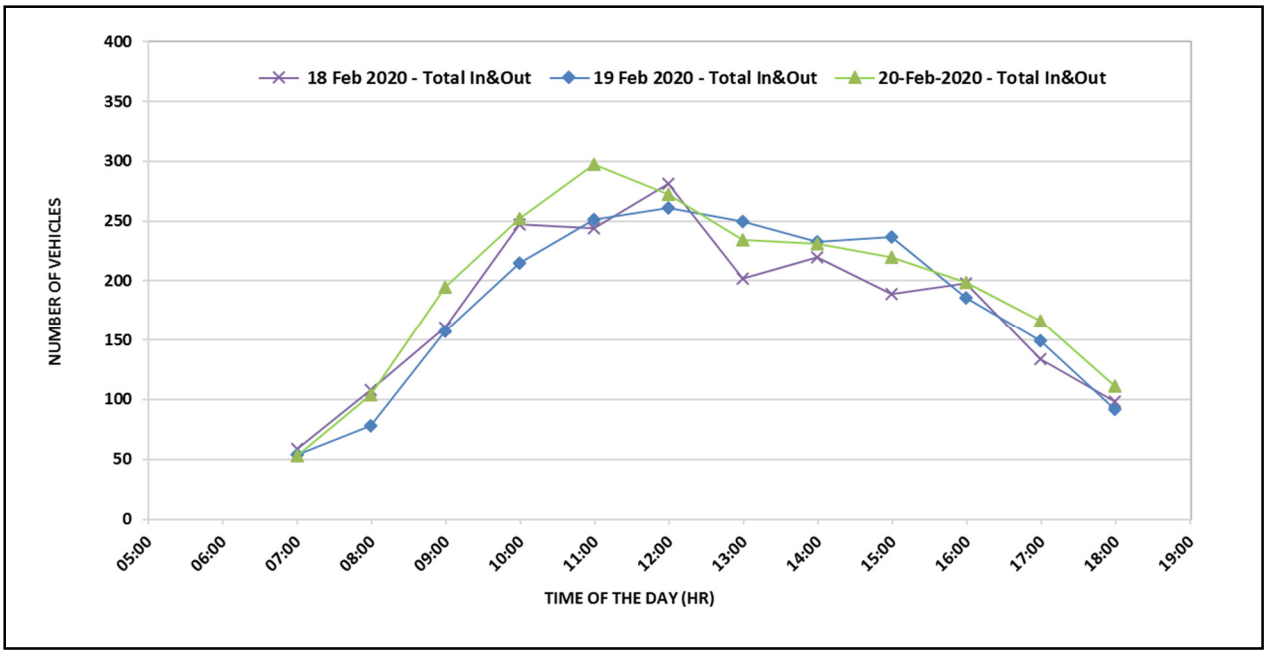


Figure 5-16: Traffic Flows Patterns before COVID-19 (Hourly) – Private Hospital 2

The results provide a clear traffic flow pattern throughout the day and reveal the increase in traffic during the day.

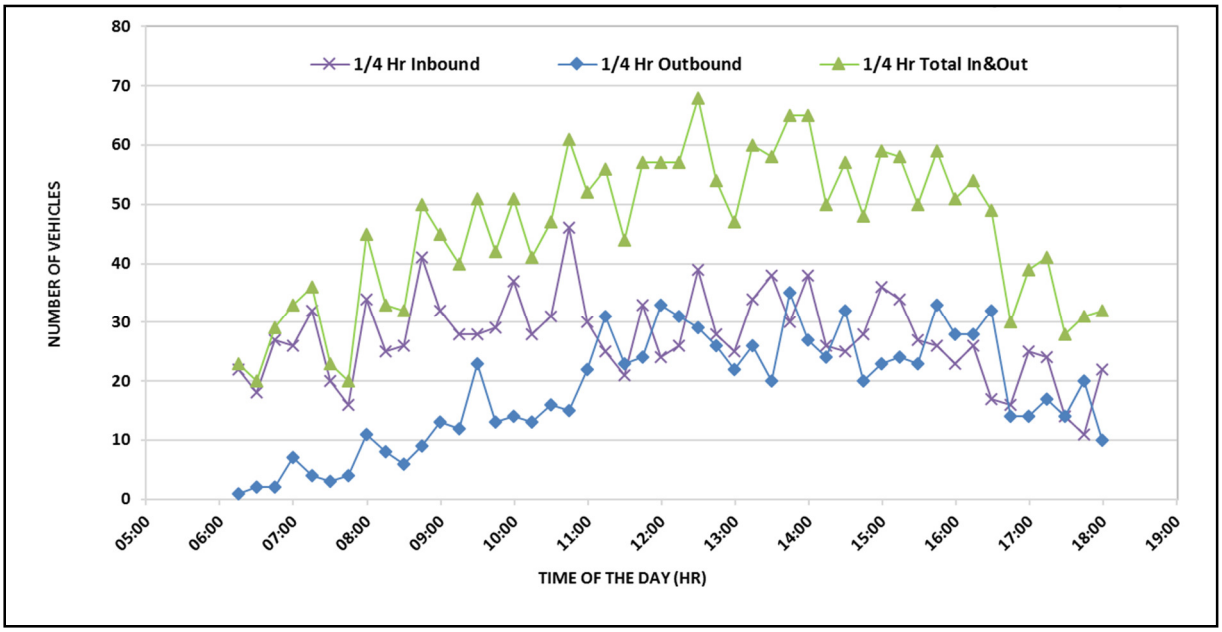


Figure 5-17: Traffic Flows Patterns before COVID-19 (15 Min) – Private Hospital 3

5.3.3 Pedestrian Volumes

The pedestrian movement at the private hospitals can be seen on **Figure 5-18**, **Figure 5-19** and **Figure 5-20** below. The employees work different shift hours, the medical team works 2 shifts. The first shift starts from 06:00 AM – 18:00 PM and the second shift starts from 18:00 PM to 06:00 AM. The administration staff and support staff (cleaners, drivers, etc) work a single shift from 08:00 AM to 16:00 PM. The graphs reflect higher pedestrian movement during the morning compared to the afternoon.

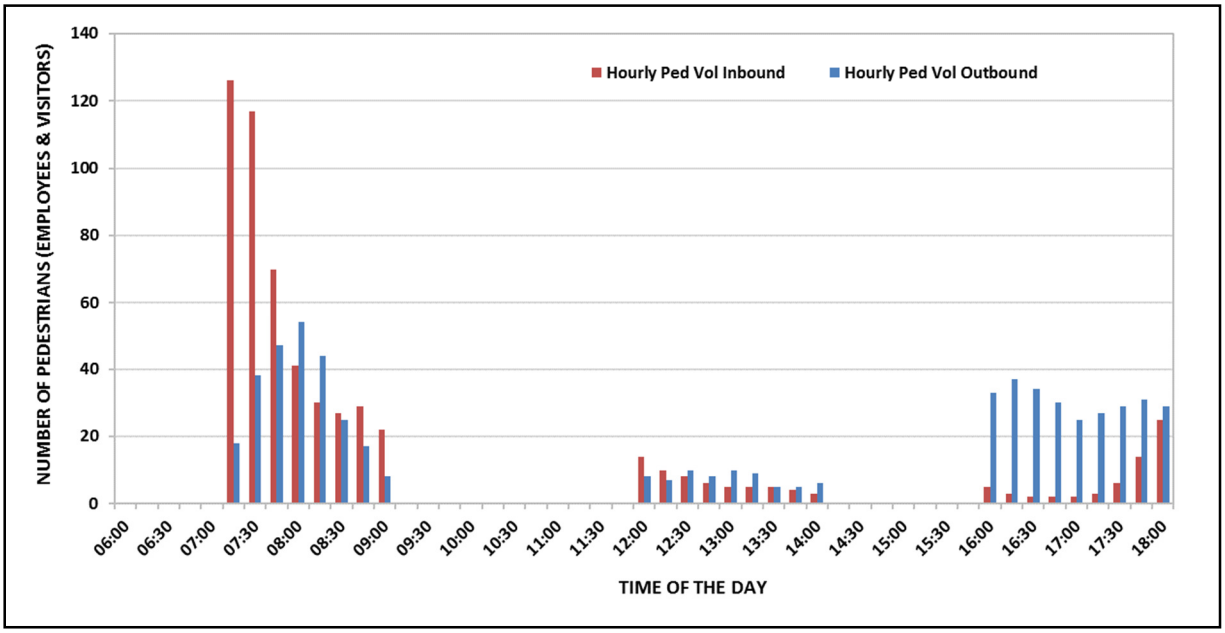


Figure 5-18: Pedestrian Volumes (Hourly) – Private Hospital 1

Pedestrian movement were mostly hospital employees and they all make use of public transport as a mode of transport. The movements are highly influenced by the work shifts at the hospital where higher volumes were recorded in the period when there are changes on the work shift.

Figure 5-18 above shows that pedestrian movements are high during the morning and afternoon peak periods. However, there was some movement during the midday even though it was very low. The pedestrian movement during the day was mainly visitors to the hospital.

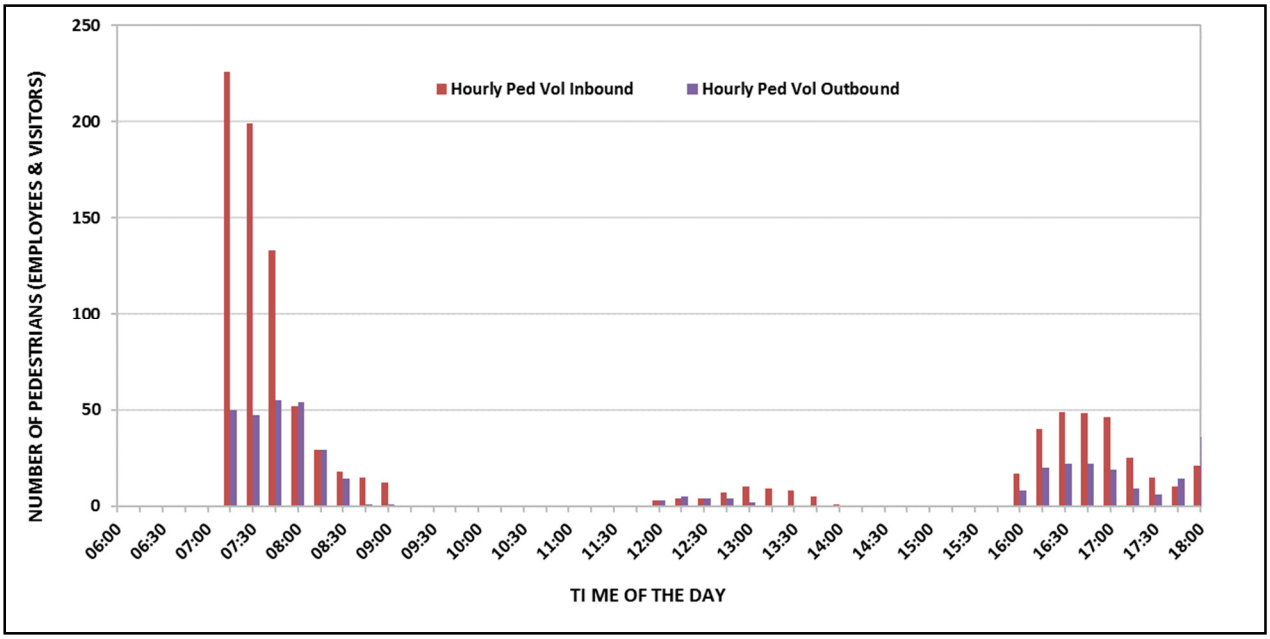


Figure 5-19: Pedestrian Volumes (Hourly) – Private Hospital 2

The figure from Private Hospital 3 below shows that there was very little pedestrian movement during the midday. The pedestrian movements at this hospital is only employees coming in and going out during the normal working shifts and very little movement during the day.

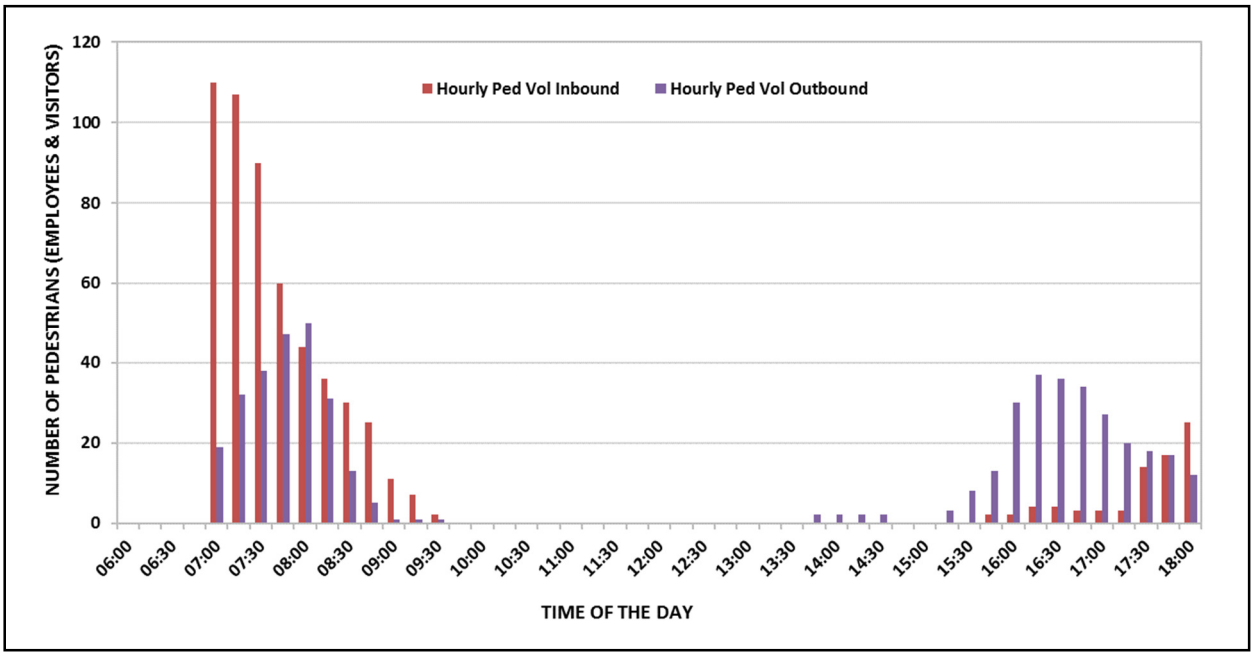


Figure 5-20: Pedestrian Volumes (Hourly) – Private Hospital 3

5.3.4 Discussion

Traffic Flow

The traffic flow results at all the three private hospitals shows typical traffic flow patterns during the morning and afternoon peak periods. In the morning there are more vehicles entering the hospital and fewer vehicles exiting the hospital and this traffic mainly comprise of hospital employees. Due to COVID-19 pandemic, some of the services at hospital had been suspended and visitors to hospitalised patients were not allowed except for emergency cases.

Data made available by two of the private hospitals for the period before the COVID-19 pandemic allows for the comparison of "normal" traffic and traffic affected by the lockdown period. **Figure 5-21** below shows the traffic change at Private Hospital 2 between data collected in July 2020 and February 2020. It can be seen that the traffic flows were relatively similar throughout the day for both pre-Covid-19 and during the Covid-19 pandemic at Private Hospital 2. However, the morning period during the Covid-19 pandemic was higher, possibly due to increase in staff movement at the hospital.

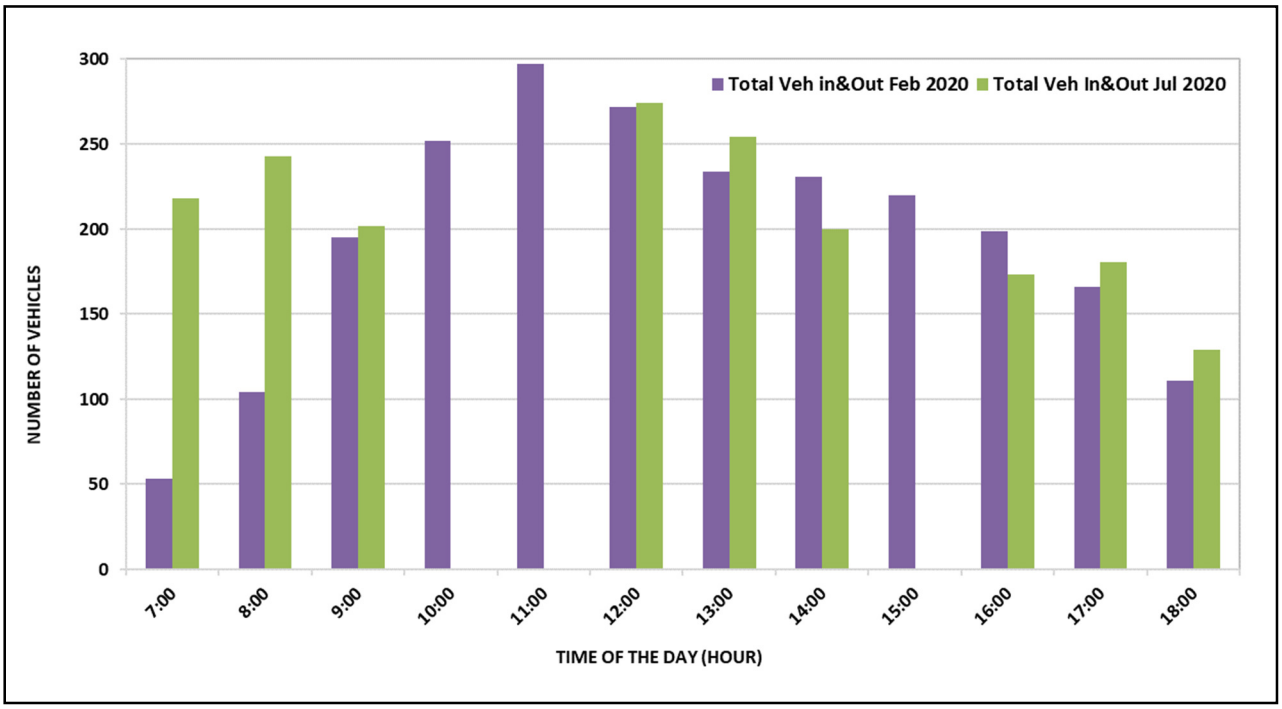


Figure 5-21: Traffic Flow Before and During COVID-19 Pandemic (Hourly) at Private Hospital 2

The comparison of the daily traffic flow at Private Hospital 3 is shown in **Figure 5-22** below. The graph shows that the traffic flow patterns during COVID-19 pandemic were mostly lower than the normal days before the lockdown. Again the morning peak hour traffic shows more traffic during COVID-19 pandemic. However, the midday results reflect that the COVID-19 pandemic traffic was less than the traffic before COVID-19.

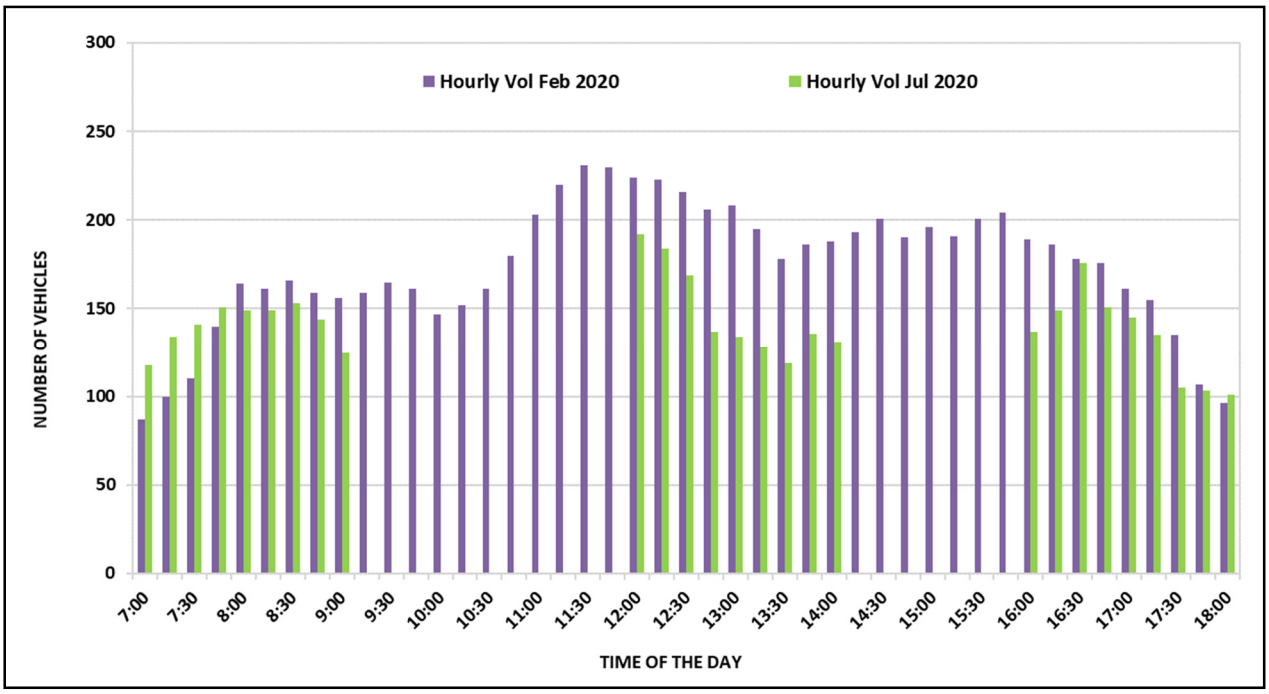


Figure 5-22: Traffic Flow Before and During COVID-19 Pandemic (15 Min) at Private Hospital 3

Pedestrian Movement

The daily pedestrian movement is prominent in the morning when most of the medical team including the administration staff come to work. The afternoon peak is dispersed because the administration staff work different shift to the medical staff. It also reflects that the staff number for the night shift is much less than the day staff. The pedestrian movement at all the private hospitals was less than the vehicle traffic flow. Pedestrian volumes at private hospitals were between 27-30% of the vehicle volumes. **Figure 5-23** below shows the difference in vehicle and pedestrian volumes from the entire 9-hour count.

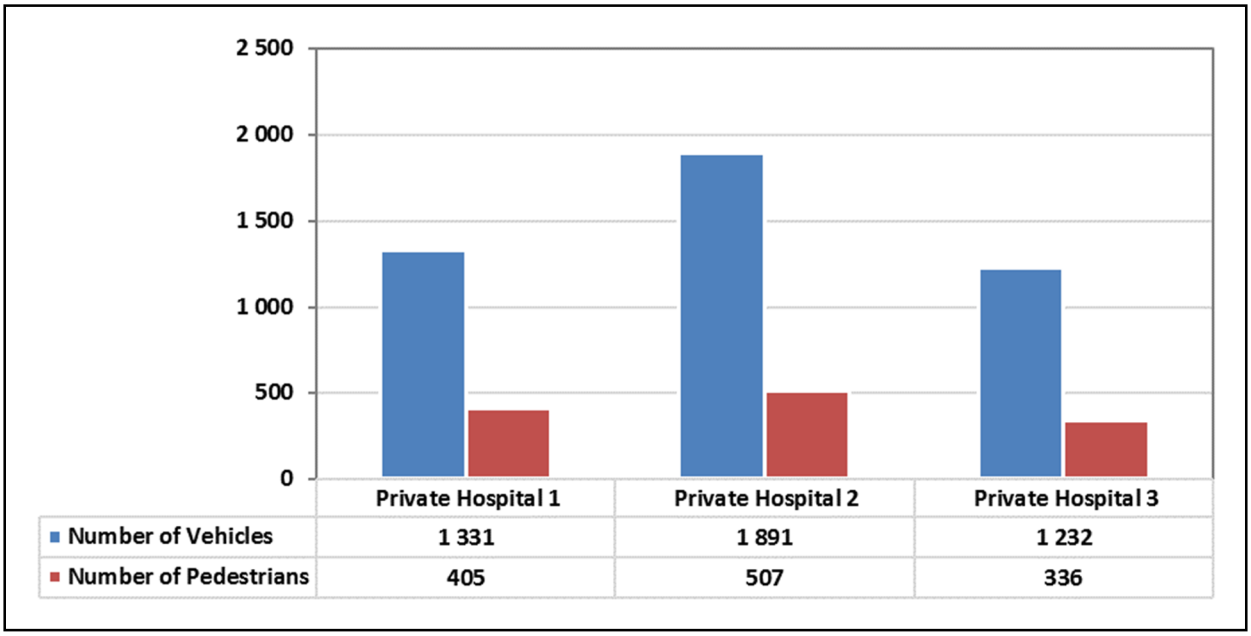


Figure 5-23: Private Hospitals Modal Split

5.4 Traffic Flow - Public Hospitals

5.4.1 Traffic Volumes

Traffic flow volumes data collected from the public hospitals was analysed and is shown in **Figure 5-24**, **Figure 5-25** and **Figure 5-26** below. The graphs show traffic directional split as well as the total of both inbound and outbound traffic flows.

The time period of the day where counts were not conducted are reflected with no data. No distinction was made between the vehicles of hospital employees and visitors during the data capturing. The data reflects a combined traffic flows captured at all hospital operational gates.

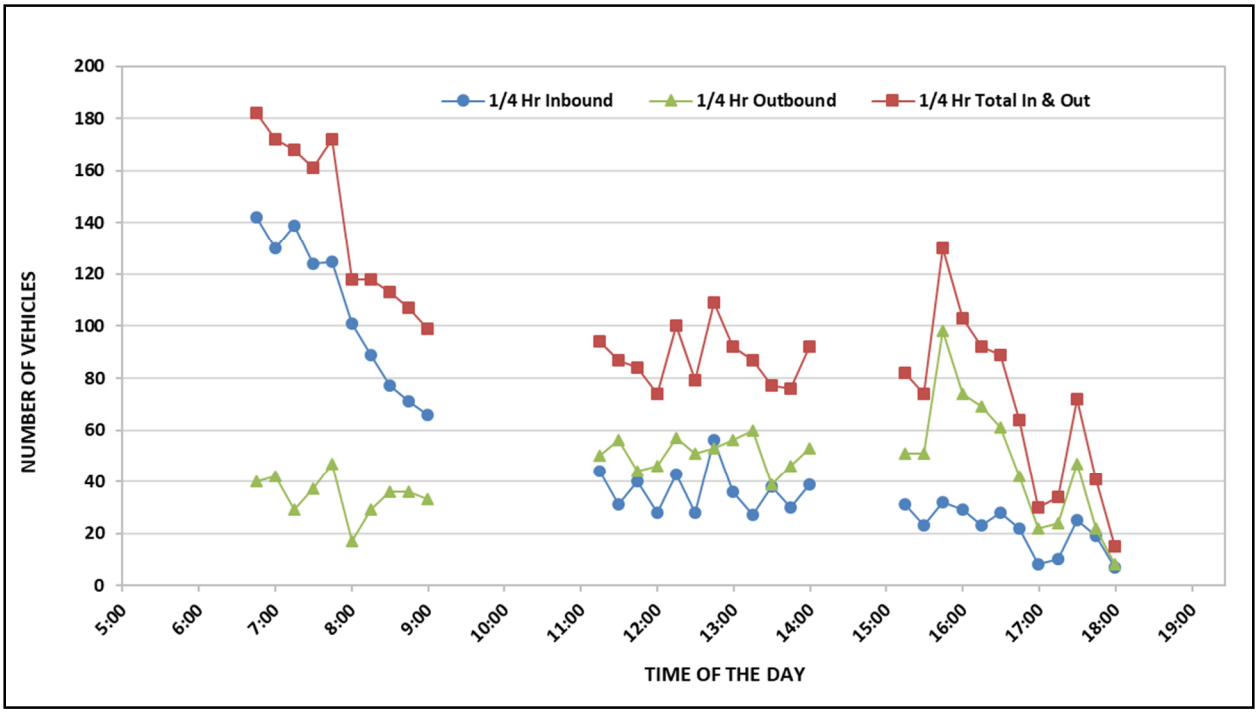


Figure 5-24: Traffic Flow Volumes (15 Min) at Helen Joseph Hospital

All the graphs show higher inbound volumes during the morning and the opposite during the afternoon. However, the morning peak hour still shows higher volumes compared to the midday and afternoon peak periods.

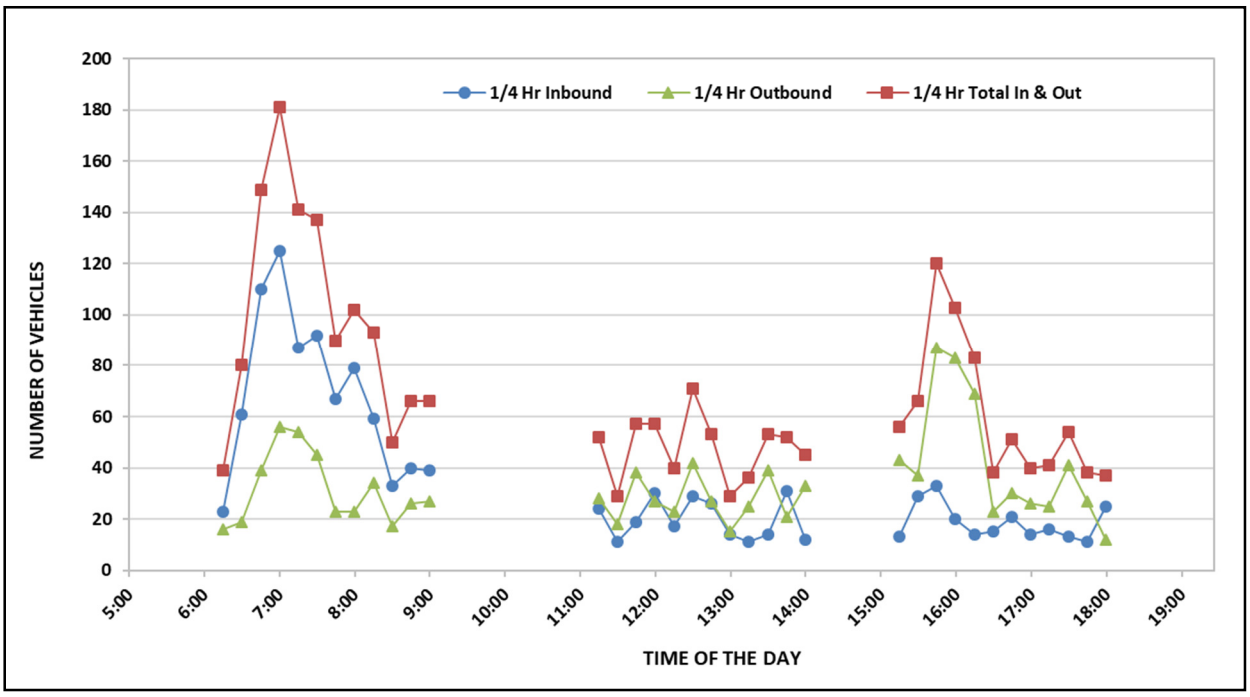


Figure 5-25: Traffic Flow Volumes (15 Min) at Tambo Memorial Hospital

The traffic flows during the midday at Edenvale are much closer to the afternoon peak volumes. From the results it is clear that Edenvale hospital generates almost half of the other hospital trips, however all the hospitals are regional according to their classification.

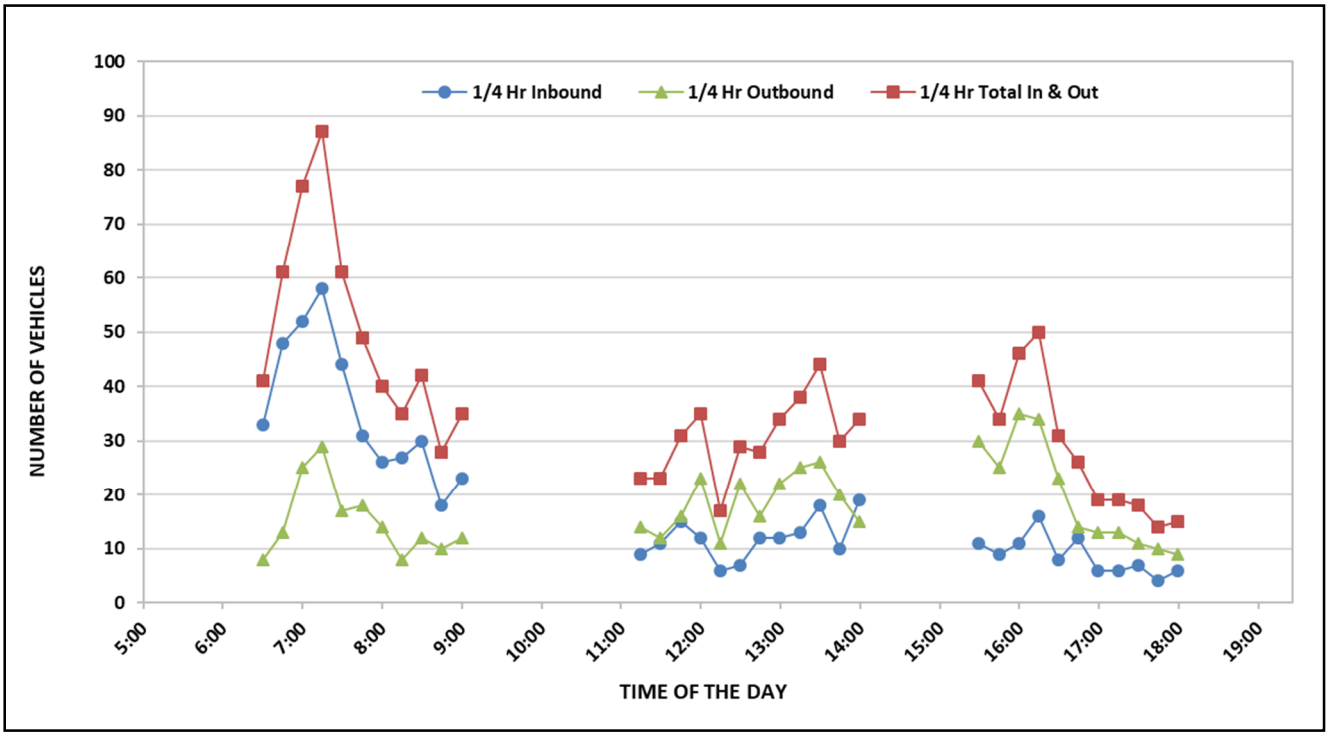


Figure 5-26: Traffic Flow Volumes (15 Min) at Edenvale Hospital

The morning occurred at similar times for the Public Hospitals and the afternoon and midday peak hour occurred at different times for all the hospitals. Refer to **Table 5-2** below for the peak hour volumes and peak hour periods.

Table 5-2: Peak Hour Volumes at Public Hospitals

Hospital (Public)	*Peak Period*	*Peak Hour*	*Peak Hour Volumes*		
			In	*Out*	*Total*
Heln Joseph Hospital	AM	06:30 - 07:30	535	148	**683**
	MIDDAY	12:00 - 13:00	163	217	**380**
	PM	15:30 - 16:30	112	302	**414**
Tambo Memorial Hospital	AM	06:30 - 07:30	414	194	**608**
	MIDDAY	11:45 - 12:45	95	130	**225**
	PM	15:15 - 16:15	96	276	**372**
Edenvale Hospital	AM	06:30 - 07:30	202	84	**286**
	MIDDAY	11:00 - 12:00	60	86	**146**
	PM	15:30 - 16:30	47	124	**171**

5.4.2 Pedestrian Volumes

The pedestrian volumes at the three public hospitals are shown in graphs below. During the morning there are more pedestrians going into the hospital and the opposite happens in the afternoon. Pedestrian volumes include both hospital employees and visitors which were only patients during COVID-19 pandemic.

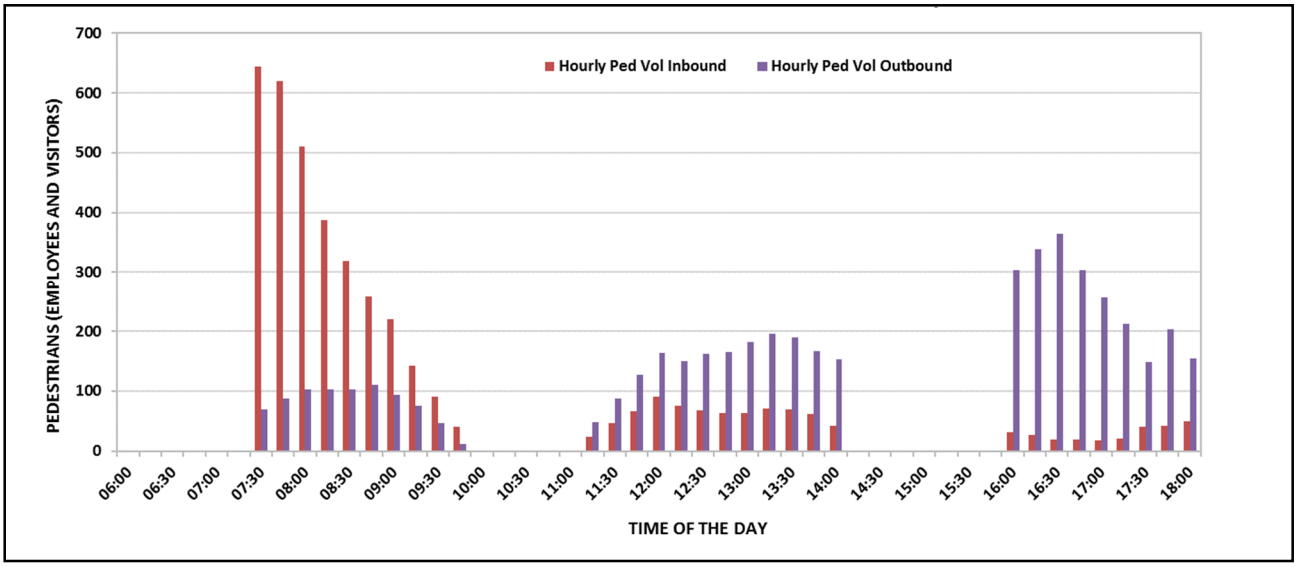


Figure 5-27: Pedestrian Volumes(15 Min) at Helen Joseph Hospital

There are more pedestrians going into the hospitals during the morning peak hour. The record highest volume was 644 pedestrians per 15-minutes going into the hospital. The

pedestrian movement during the mid-day peak mostly includes patients visiting the hospital.

Figure 5-28 below shows very low pedestrian volumes coming into the hospital during the afternoon but the outbound remains relatively the same from midday period.

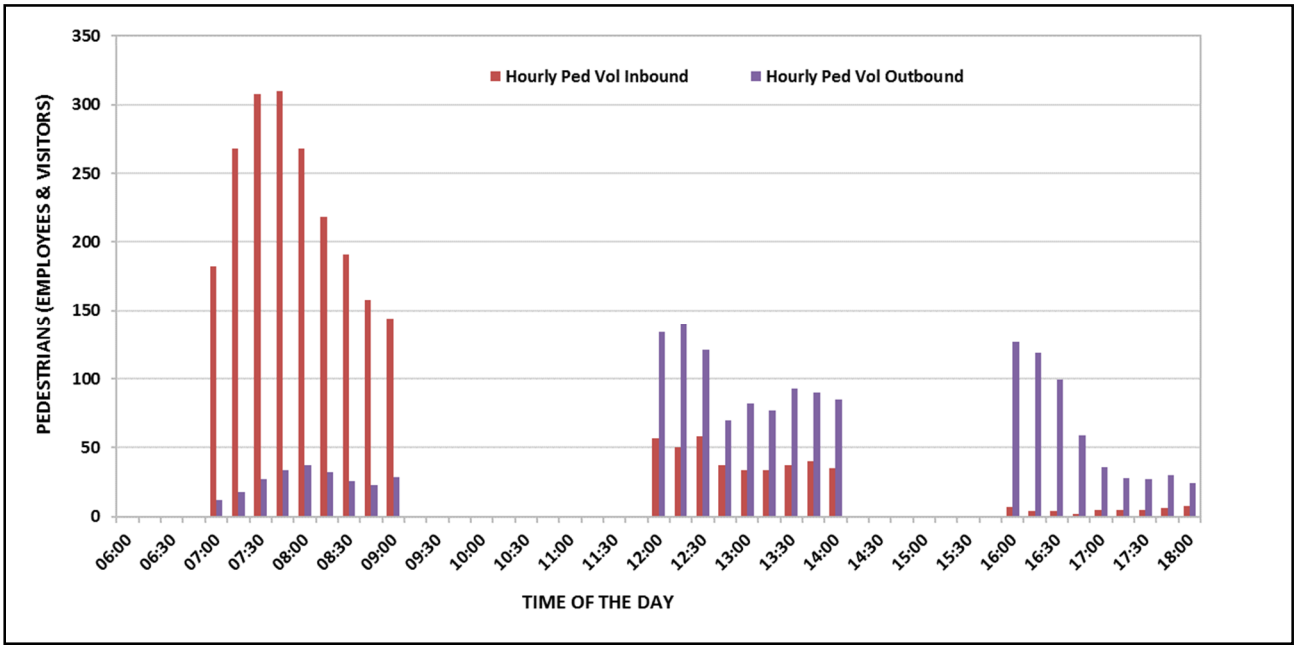


Figure 5-28: Pedestrian Volumes (15 Min) at Tambo Memorial Hospital

Figure 5-29 below shows very high pedestrian volumes coming into the hospital during the morning peak hour and but the strong outbound during the midday and afternoon peak periods.

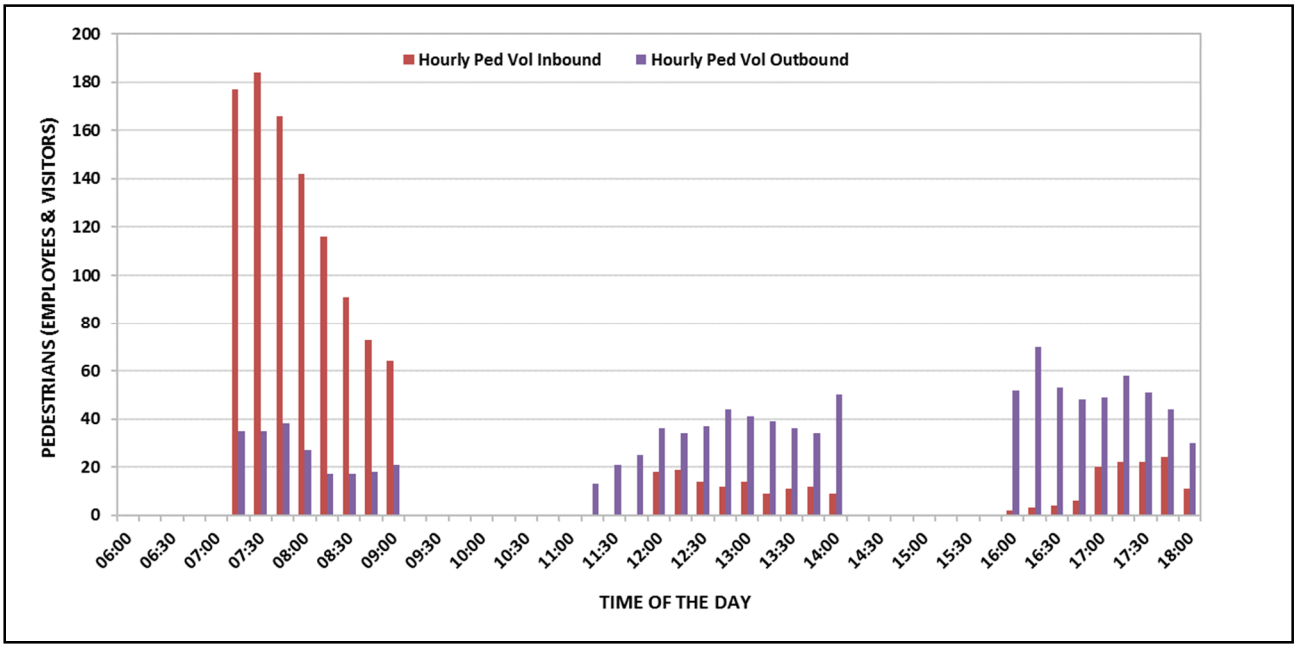


Figure 5-29: Pedestrian Volumes at Edenvale Hospital

5.4.3 Discussion

Traffic Flow

The traffic flow patterns at public hospitals also reflects typical traffic flow patterns, with more traffic going into the hospital during the morning than during the afternoon, and more trips exiting the hospital in the afternoon. There was no previous data to quantify the changes in traffic flow patterns during the COVID-19 pandemic and the period before the pandemic. However, as shown in *Section 5.2* above with the Google Earth imagery of hospital parking areas, it can be concluded that the there was less traffic at hospitals during the COVID-19 pandemic.

Pedestrian Movement

The pedestrian movement at public hospitals had a similar pattern to the vehicle movement at all the hospitals. The pedestrian movement were however more at all the public hospitals compared to the private hospitals. The reason for major pedestrian volumes is not only from the hospital employees but also a considerable number of patients that arrived using public transport and then entered or exited the hospital premises on foot. The percentage of pedestrians to vehicles at public hospitals ranged

between 64% to 82%. **Figure 5-30** below shows the pedestrian volumes versus vehicle volumes from the 9-hour counts.

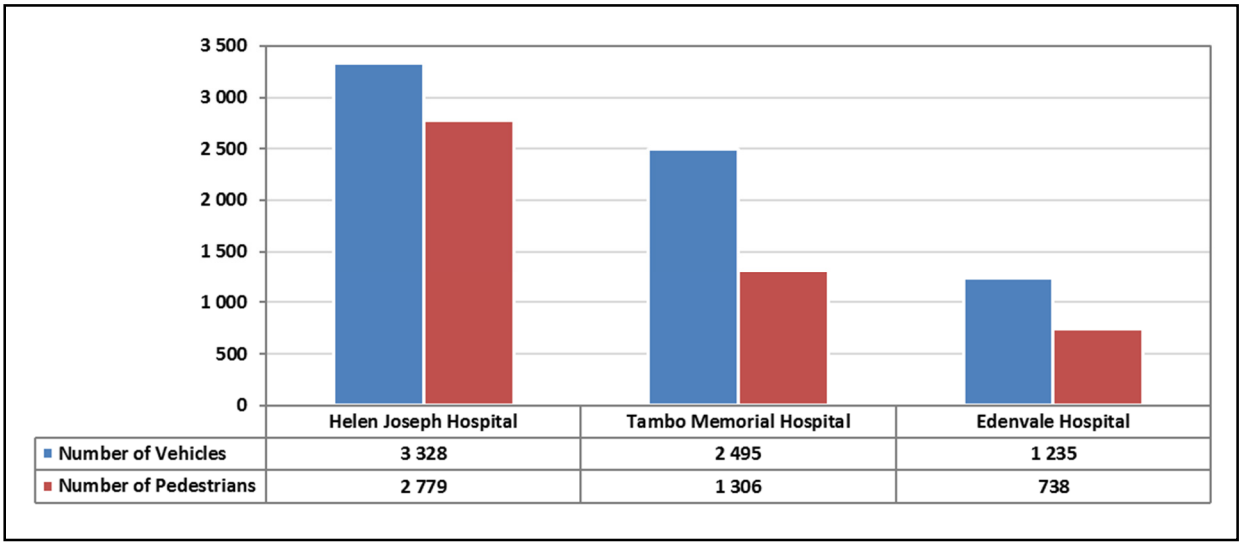


Figure 5-30: Public Hospitals Modal Split

5.5 Trip Generation

Trip generation is a number of vehicle trips going in and out of the development per hour. Trip generation factors are used to estimate the number of trips attracted and produced by any type of land use. These factors are particular for each of land use. In other words, the number of trips attracted by the hospital and the number of trips produced by the hospital can be estimated by use of trip generation indicators for either private or public hospital. The following equation is used to estimate the trip generation or number of trips per land use. These factors may also differ per time of the day, e.g. the morning trip generation may be higher or lower than the afternoon peak hour.

$$\text{Trip Generation Rate} = \frac{\text{Number of Trips Generated}}{\text{Independent Variable*}} \qquad \textbf{(Equation 2)}$$

Independent variables* for hospitals include:

- number of beds,
- Gross Leasable Area and
- Spaces per practitioners (consulting rooms).

The traffic count data presented in *Section 5.1* and *Section 5.2* above and the hospital information is Chapter 4 was used to calculate the trip generation rate per peak hour period. This data was then used to calculate the trip generation rate for each peak period as shown in *Sections 5.5.1* and *Section 5.5.2* below.

5.5.1 Trip Generation for Private Hospitals

The trip generation rates for each hospital were calculated by using the number of used hospital beds. Private Hospital 1 on **Table 5-3** below shows the lowest trip rate of 0.41 trips/bed during the afternoon peak period. The highest trip rate is at Private Hospital 2 with 1.14 trips/bed during the morning peak hour. The average morning and afternoon peak hour trip generation rates were also calculated from the peak hours' trip rates of the three private hospitals.

Table 5-3: Measured Peak Hour Trip Generation Rates for Private Hospitals (Private Vehicles only)

Hospital (Private)	*Peak Hour*	*Peak Hour Vehicles*	*Directional Split*		*Number of Beds*	*Trip Rate / Bed*
			In	*Out*		
Private Hospital 1	AM	163	64%	36%	363	0,45
	MIDDAY	219	47%	53%		0,60
	PM	148	26%	74%		0,41
Private Hospital 2	AM	318	81%	19%	279	1,14
	MIDDAY	282	46%	54%		1,01
	PM	212	61%	39%		0,76
Private Hospital 3	AM	151	83%	17%	200	0,76
	MIDDAY	192	53%	47%		0,96
	PM	176	28%	72%		0,88
Average Values	***AM***		***76%***	***24%***		***0,78***
	PM		***39%***	***61%***		***0,68***

The directional split shows higher inbound percentages for the morning peak hour and vice versa for the afternoon peak hour, the midday peak hour was relatively balanced. The afternoon peak hour directional split for Private Hospital 2 still reflect higher inbound percentage which is very different from other hospitals and the typical split from the

manuals. The average directional split for private hospitals were also estimated from the peak hour directional split. The above calculations were only based on number of private vehicles counted.

A trip generation rate that includes public transport vehicles is shown in **Table 5-4** below. During the data collection, it was observed that taxis dropped or picked up between 1 and 4 passengers, to and from the hospital. Therefore, an average of 2 passengers per taxi was used to estimate the number of public transport from the pedestrian volumes. The analysis with public transport shows a slight difference in the trip generation rates for each hospital. The highest trip rate is 1.58 trips per bed at Private Hospital 2. The average trip generations rates for morning and afternoon peak hours were found to be 1.09 trips per bed and 0.77 trips per bed respectively.

Table 5-4: Measured Peak Hour Trip Generation Rates for Private Hospitals (Private Vehicles plus Public Transport)

Hospital (Private)	*Peak Hour*	*Peak Hour Vehicles*	*Directional Split*		*Number of Beds*	*Trip Rate / Bed*
			In	*Out*		
Private Hospital 1	AM	241	68%	32%	363	0,66
	MIDDAY	228	47%	53%		0,63
	PM	166	24%	76%		0,46
Private Hospital 2	AM	441	81%	19%	279	1,58
	MIDDAY	288	46%	53%		1,03
	PM	248	62%	38%		0,89
Private Hospital 3	AM	205	76%	24%	200	1,02
	MIDDAY	192	53%	47%		0,96
	PM	196	27%	73%		0,98
Average Values	***AM***		***75%***	***25%***		***1,09***
	PM		***38%***	***62%***		***0,77***

5.5.2 Trip Generation for Public Hospitals

The measured trip generation rates for each public hospital are shown in **Table 5-5** below. The average trip generation for each time period was calculated only from the private vehicles and they are all based on the number of beds per hospital. The highest average

trip rate is 1.11 trips/bed during the morning peak hour at Helen Joseph Hospital and the trip rate was 0.60 trips/bed at Edenvale Hospital. The average trip rates were also obtained from the three public hospital peak hour trip rates.

Table 5-5: Measured Peak Hour Trip Generations Rates for Public Hospitals (Private Vehicles Only)

Hospital (Public)	*Peak Hour*	*Peak Hour Vehicles*	*Directional Split*		*Number of Beds*	*Trip Rate / Bed*
			In	*Out*		
Helen Joseph Hospital	AM	683	78%	22%	616	1,11
	MIDDAY	380	43%	57%		0,62
	PM	414	27%	73%		0,67
Tambo Memorial Hospital	AM	608	68%	32%	604	1,01
	MIDDAY	225	42%	58%		0,37
	PM	372	26%	74%		0,62
Edenvale Hospital	AM	286	71%	29%	287	1,00
	MIDDAY	146	41%	59%		0,51
	PM	171	27%	73%		0,60
Average Values	***AM***		***72%***	***28%***		***1,04***
	PM		***27%***	***73%***		***0,63***

The trip generation rates for public hospital were also analysed by adding the private vehicle trips with the public transport trips. Public transport trips were determined by using the pedestrian volumes and an average occupation of 2 persons per taxi. **Table 5-6** below shows the adjusted peak hour vehicle trips which now include the public transport trips and the associated trip generation rates per bed.

The average trip rates for public hospitals were obtained from the peak hour trip generation rates of the three hospitals. The average peak hour trip rates were 1.45 trips per bed and 0.81 trips per bed for the morning and afternoon peak hour respectively.

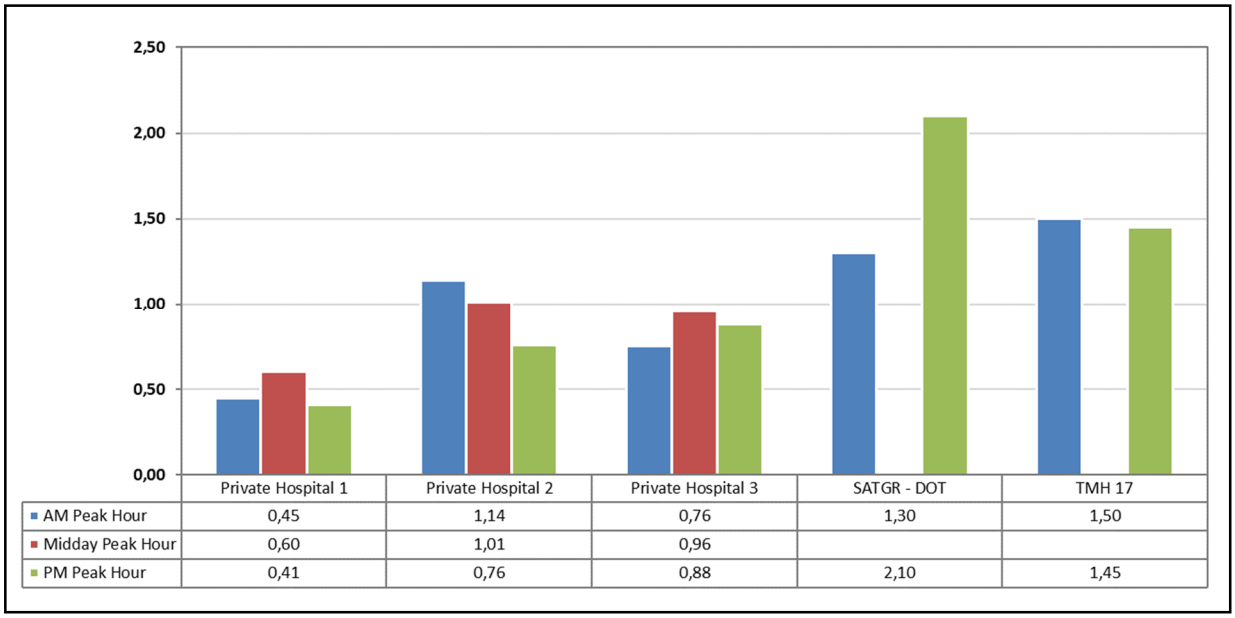
Table 5-6: Measured Peak Hour Trip Generations Rates for Public Hospitals (Private Vehicles plus Public Transport)

Hospital (Public)	*Peak Hour*	*Peak Hour Vehicles*	*Directional Split*		*Number of Beds*	*Trip Rate / Bed*
			In	*Out*		
Helen Joseph Hospital	AM	1 040	82%	18%	616	1,69
	MIDDAY	503	39%	61%		0,82
	PM	606	20%	80%		0,98
Tambo Memorial Hospita	AM	780	73%	27%	604	1,29
	MIDDAY	321	39%	59%		0,53
	PM	434	23%	77%		0,72
Edenvale Hospital	AM	396	74%	26%	287	1,38
	MIDDAY	176	37%	63%		0,61
	PM	208	23%	77%		0,72
Average Values	***AM***		***77%***	***23%***		***1,45***
	PM		***22%***	***78%***		***0,81***

5.5.3 Discussions of Trip Generation Rates

Private Hospitals

The trip generation for private hospitals shows lower trip rates compared to the existing recommended rates by the official manuals. The measured average peak hour vehicle trips per bed are almost half the recommended rates by the SATGR manual. **Figure 5-31** below shows the existing recommended trip generation rates for private hospitals compared to the measured peak hour trip generation rates from the three private hospitals. The measured trip generation rated were obtained from private vehicles only and do not include the public transport trips.

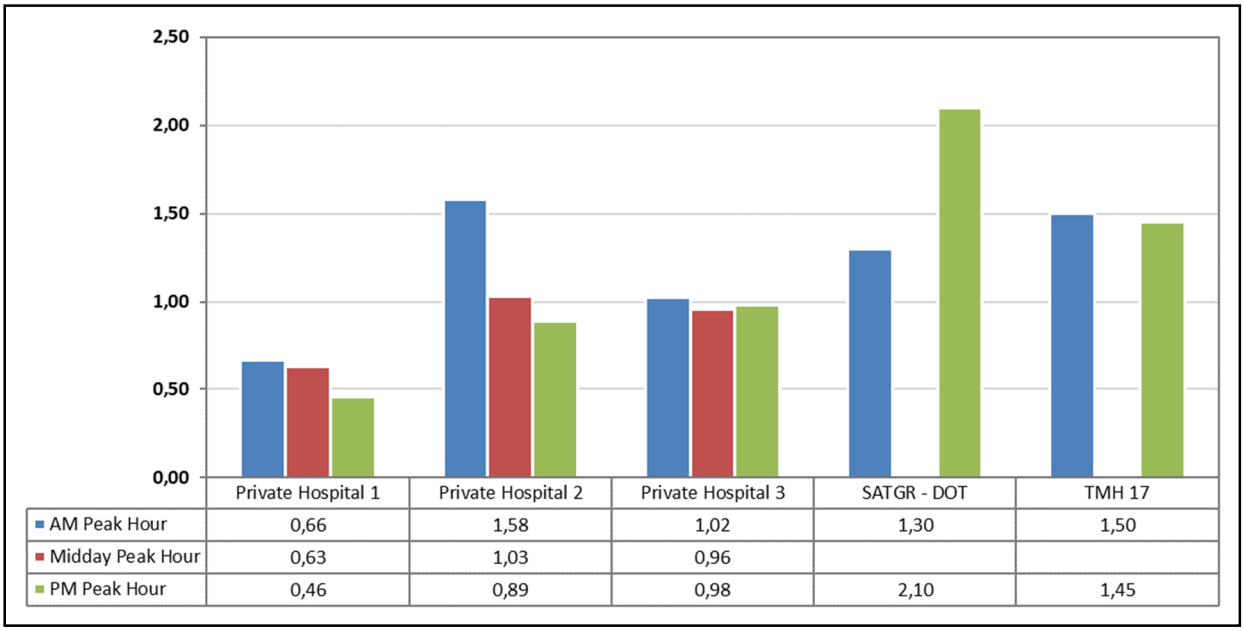


	Private Hospital 1	Private Hospital 2	Private Hospital 3	SATGR - DOT	TMH 17
AM Peak Hour	0,45	1,14	0,76	1,30	1,50
Midday Peak Hour	0,60	1,01	0,96		
PM Peak Hour	0,41	0,76	0,88	2,10	1,45

Figure 5-31: Measured vs Existing Trip Generations Rates for Private Hospitals (Private Vehicles Only)

The existing trip generation rates in the SATGR and TMH 16 manuals make provision for public transport. **Figure 5-32** below shows the trip generation rates incorporating the public transport trips. The figure shows slightly higher trip generation compared to Figure 5-31 above which only took into consideration private vehicle trips.

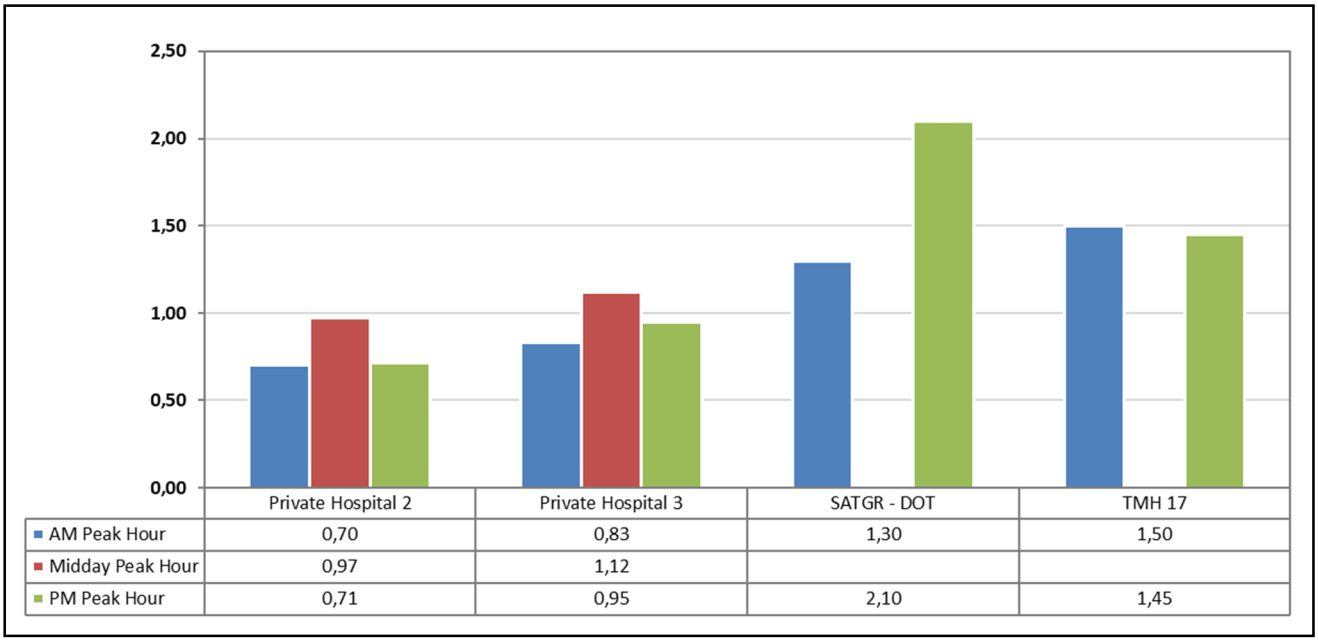
The trip generation rates were still lower than the recommended trip rates except the morning peak hour trip generations rates for Private Hospital 2, which shows higher trip rates compared to the recommended trip rates from both manuals. The lower trip generation rates could be due to the COVID-19 lockdown travel restrictions resulting in lower traffic flow patterns and therefore; lower trip generation rates.



	Private Hospital 1	Private Hospital 2	Private Hospital 3	SATGR - DOT	TMH 17
AM Peak Hour	0,66	1,58	1,02	1,30	1,50
Midday Peak Hour	0,63	1,03	0,96		
PM Peak Hour	0,46	0,89	0,98	2,10	1,45

Figure 5-32: Measured vs Existing Trip Generations Rates for Private Hospitals (Private Vehicles plus Public Transport)

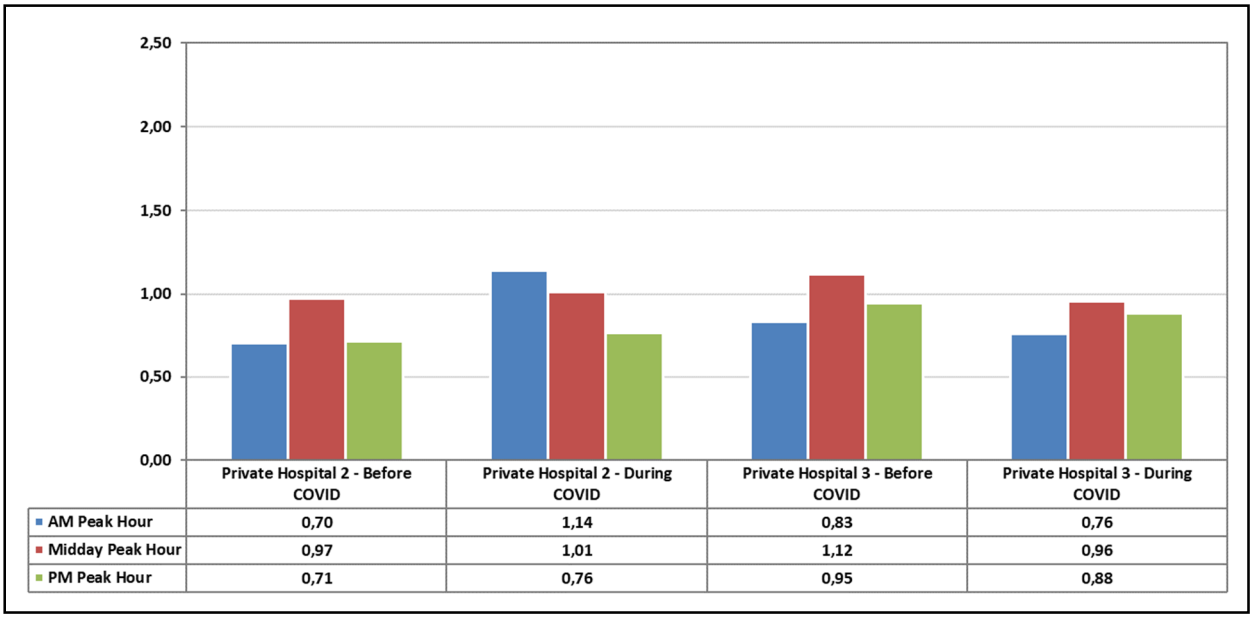
The trip generation rates estimated from the data received from the hospital records for the period pre-COVID-19 are also lower than the recommended rates from the manuals. **Figure 5-33** below shows factors estimated from February 2020 data. The trip factors are more similar to the estimates from July 2020 data and far different from the existing trip rates. The trip generation rates are only based on private vehicle trips. The private hospitals do not keep record of pedestrian movements in and out of the hospital premises. Therefore; the trip rates below do not include public transport trips.



	Private Hospital 2	Private Hospital 3	SATGR - DOT	TMH 17
AM Peak Hour	0,70	0,83	1,30	1,50
Midday Peak Hour	0,97	1,12		
PM Peak Hour	0,71	0,95	2,10	1,45

Figure 5-33: Trip Generation Rates for Private Hospitals estimated from the data before COVID-19 (Private Vehicles Only)

A comparison of trip generation rates for private hospitals, from data before COVID-19 and during COVID-19 is shown in **Figure 5-34** below. The figure shows that the trip generation rates at these two private hospitals were not insignificantly different. The trip generation rates for Private Hospital 2 shows the higher trip generation rates during COVID-19 in the morning, the midday and afternoon are slightly similar. The trip generation rates below are only based on vehicle trips and number of hospital beds.

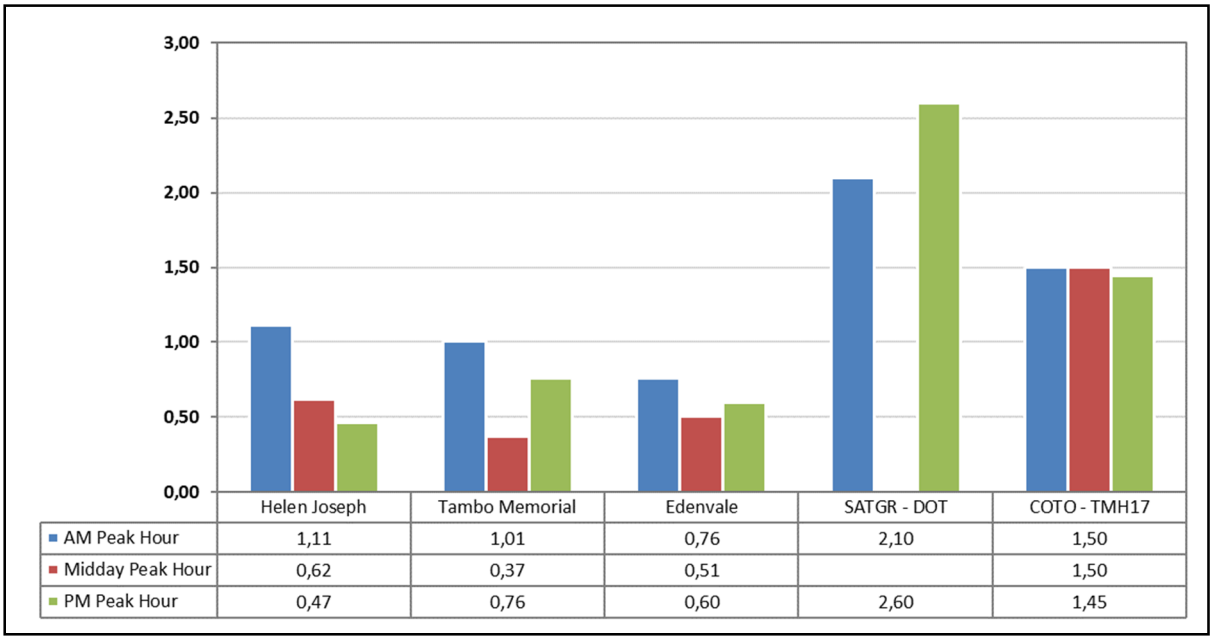


	Private Hospital 2 - Before COVID	Private Hospital 2 - During COVID	Private Hospital 3 - Before COVID	Private Hospital 3 - During COVID
AM Peak Hour	0,70	1,14	0,83	0,76
Midday Peak Hour	0,97	1,01	1,12	0,96
PM Peak Hour	0,71	0,76	0,95	0,88

Figure 5-34: Measured Trip Generations Rates for Public Hospitals Before and During COVID-19

Public Hospitals

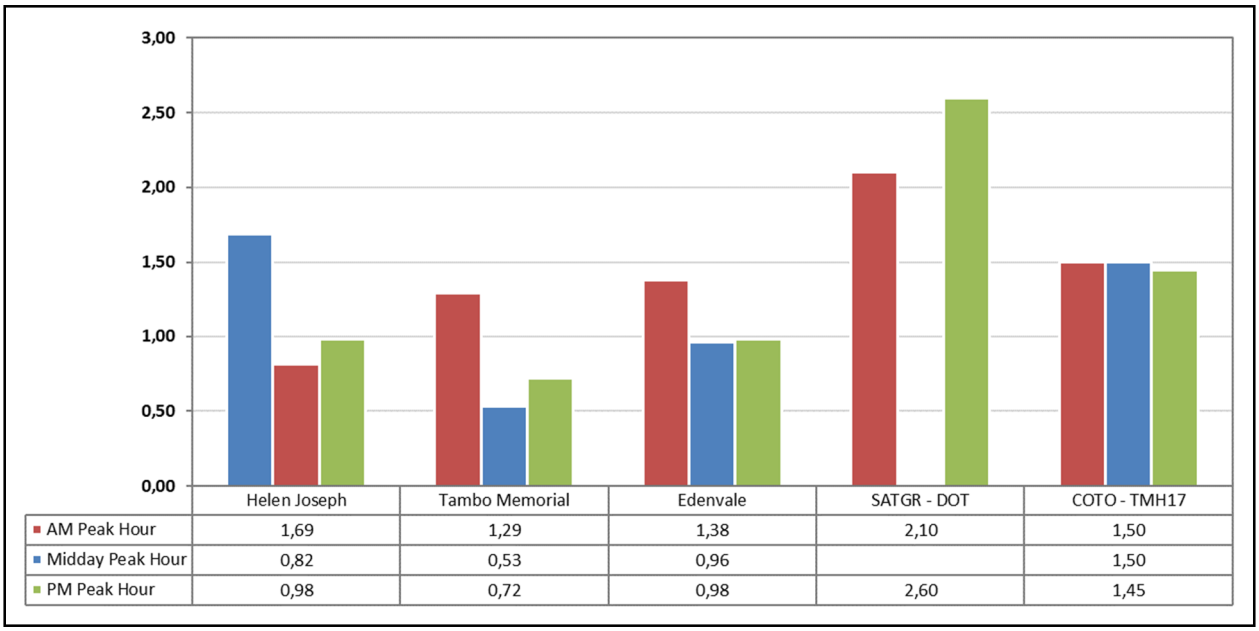
The measured trip generation rates for public hospitals were also lower than the trip generation rates recommended in the manuals as shown in **Figure 5-35** below. As mentioned before, the trip generation rates in the manuals include the public transport trips. The results in Figure 5-35 are based on private vehicles and exclude public transport trips. The trip generation rates measured at three of the public hospitals are only half of the recommended trips by the SATGR manual (Stander, et. al. 1995).



	Helen Joseph	Tambo Memorial	Edenvale	SATGR - DOT	COTO - TMH17
AM Peak Hour	1,11	1,01	0,76	2,10	1,50
Midday Peak Hour	0,62	0,37	0,51		1,50
PM Peak Hour	0,47	0,76	0,60	2,60	1,45

Figure 5-35: Measured Trip Generations Rates for Public Hospitals Before and During COVID-19 (Private Vehicles Only)

Figure 5-36 below shows the trip generation rates based on both private vehicles and public transport. The figure shows slightly higher trip generation compared Figure 5-35 above. To obtain the public transport trips, an average of 2 pedestrians per taxi was assumed which is in-line with the observation made during the data collection.



	Helen Joseph	Tambo Memorial	Edenvale	SATGR - DOT	COTO - TMH17
AM Peak Hour	1,69	1,29	1,38	2,10	1,50
Midday Peak Hour	0,82	0,53	0,96		1,50
PM Peak Hour	0,98	0,72	0,98	2,60	1,45

Figure 5-36: Measured Trip Generations Rates for Public Hospitals Before and During COVID-19 (Private Vehicles plus Public Transport)

Although the trip generation rates with the inclusion of the public transport trips are slightly higher at public hospitals, they are still lower than the recommended trip rates from the existing manuals.

The results of lower trip generation during COVID-19 pandemic, for both public and private hospitals were expected due to the travel restrictions during the lockdown. However, the results from data captured before COVID-19 pandemic still shows lower trip generation rates.

5.6 Parking Demand

The analyses comprise of evaluation of parking characteristics including parking accumulation, parking index and parking demand which were analysed based on the traffic count data. The parking demand was measured by the difference between cumulative inbound and outbound vehicles. Accumulation is the sum of the overall vehicles parking in the parking lot during a certain time period. The results do not include the vehicles that were already parked inside the hospital at the start of the count. These would be very few vehicles of employees working the night shift.

5.6.1 Parking Demand at Private Hospitals

The parking accumulation for vehicles parked per 15 minutes at each of the private hospitals are shown in **Figure 5-37**, **Figure 5-38** and **Figure 5-39** below. The parking duration per vehicle was not measured however, the records from hospital 3 provided the parking duration before COVID-19 pandemic.

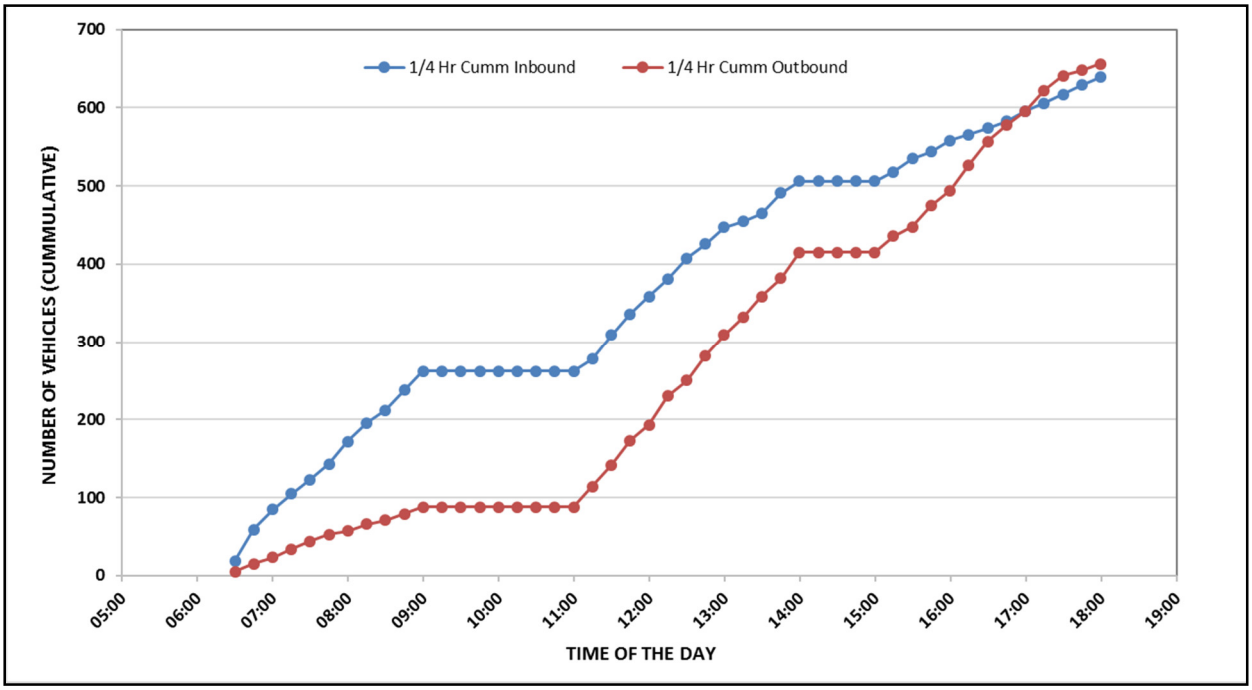


Figure 5-37: Cumulative Traffic Flow Volumes at Private Hospital 1

The morning peak period was the most critical with high traffic flows and therefore was used to evaluate the parking demand. The difference in traffic volumes varied between 46 and 71 vehicles per hour at Private Hospital 1.

Private Hospital 2 had a higher range in the traffic flow difference between inbound and outbound traffic volumes. (Refer to Figure 5-38 below) The hourly difference varied between 95 and 231 vehicles per hour.

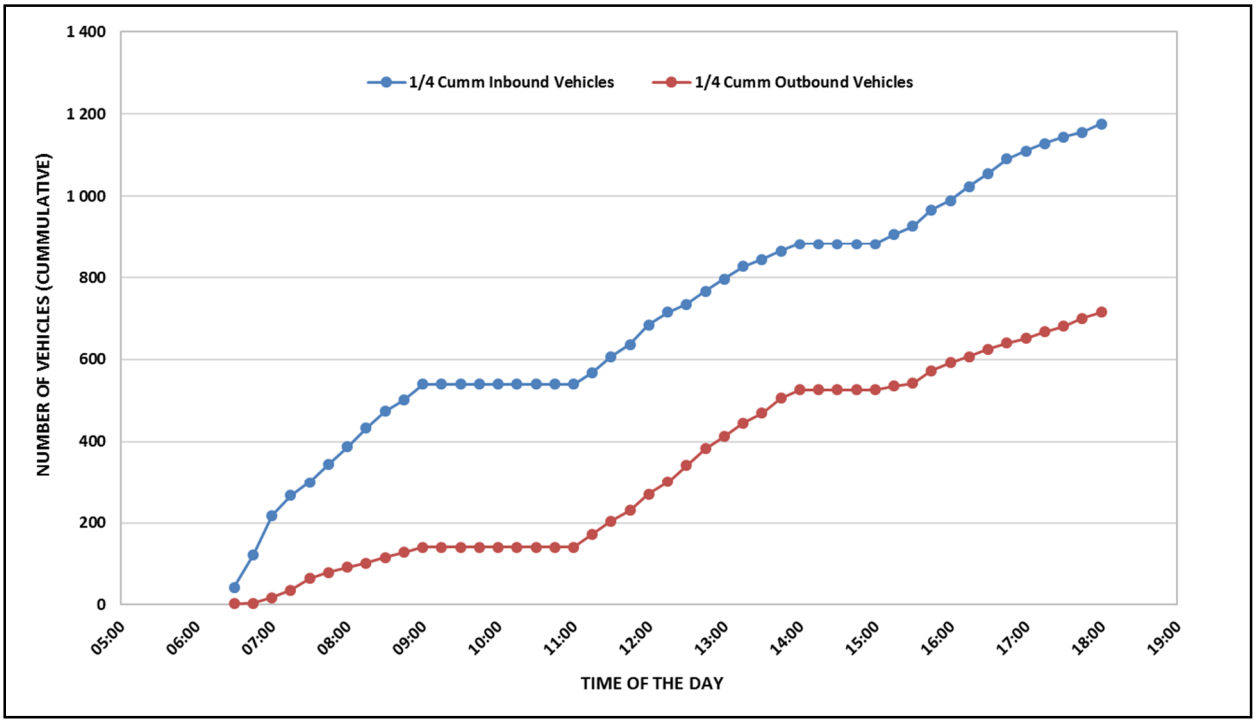


Figure 5-38: Cumulative Traffic Flow Volumes at Private Hospital 2

The cumulative traffic volumes for Private Hospital 3 were compared for both before and during COVID-19 pandemic data in **Figure 5-39** below. It can be noted that the graph from data before COVID-19 pandemic has higher values due to the continuity of data capturing. The maximum difference between inbound and outbound traffic volumes were 111 and 101 vehicles per hour for pre and during COVID-19 data respectively.

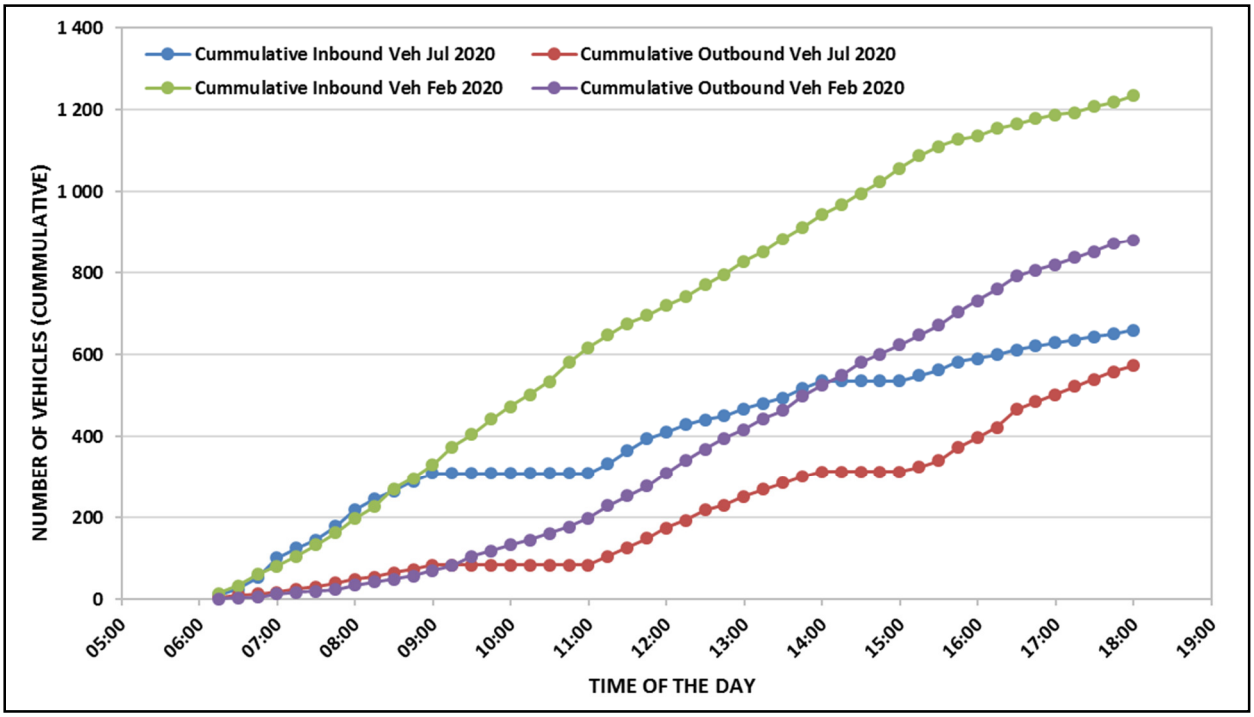


Figure 5-39: Cumulative Traffic Flow Volumes at Private Hospital 3

5.6.2 Parking Demand at Public Hospitals

The parking accumulation for vehicles parked per 15 minutes at each of the public hospitals are shown in **Figure 5-40**, **Figure 5-41** and **Figure 5-42** below. The parking duration per vehicle was not measured and neither were the parked vehicles before and at the end of the survey. The flat areas on the graphs reflect the period of the day where counts were not conducted.

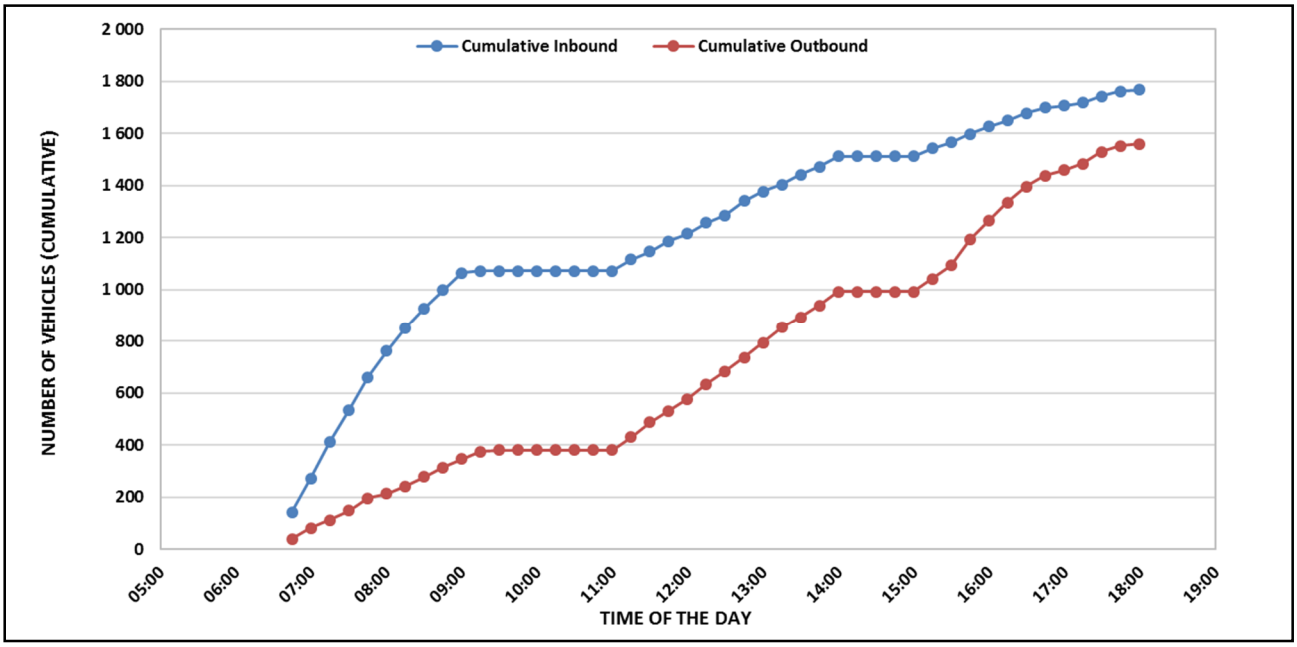


Figure 5-40: Cumulative Traffic Flow Volumes at Helen Joseph Hospital

The maximum difference between cumulative traffic volumes was about 574 vehicles during the morning peak period at Helen Joseph Hospital. The figures below for Tambo Memorial Hospital and Edenvale Hospital shows less difference between the inbound and outbound traffic compared to Helen Joseph hospital above.

All the figures reflect a larger gap during the morning and it changes towards the end of the day when the gap becomes smaller.

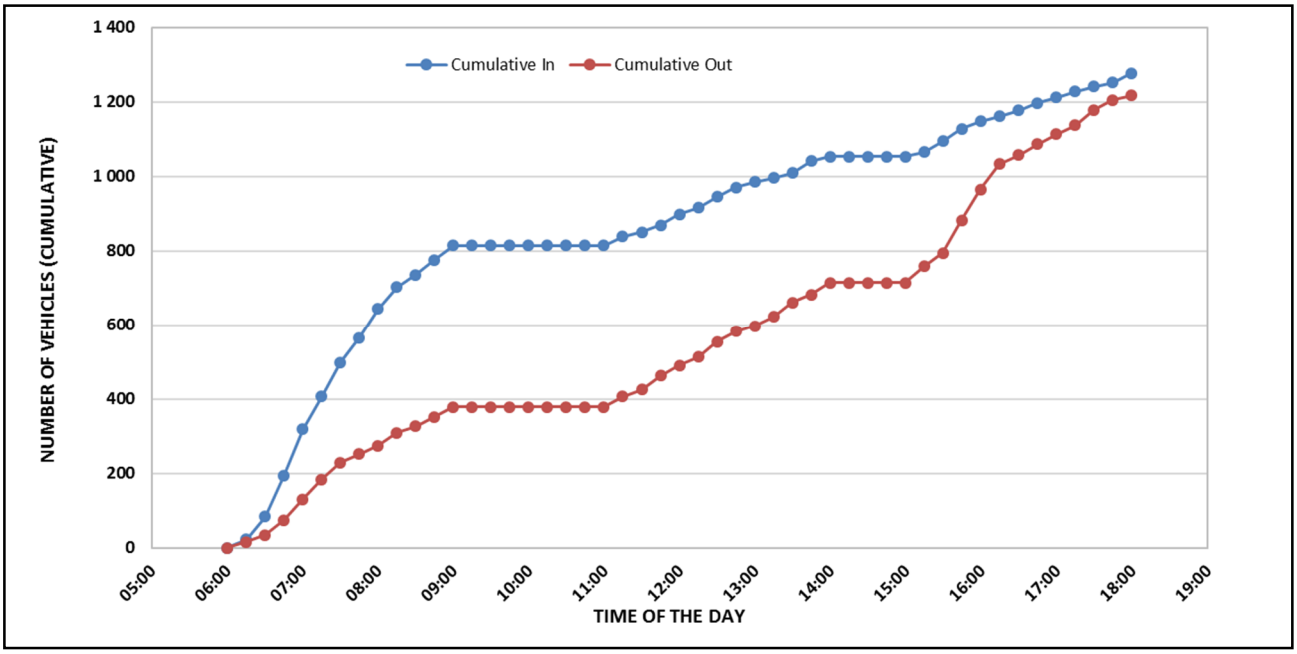


Figure 5-41: Cumulative Traffic Flow Volumes at Tambo Memorial Hospital

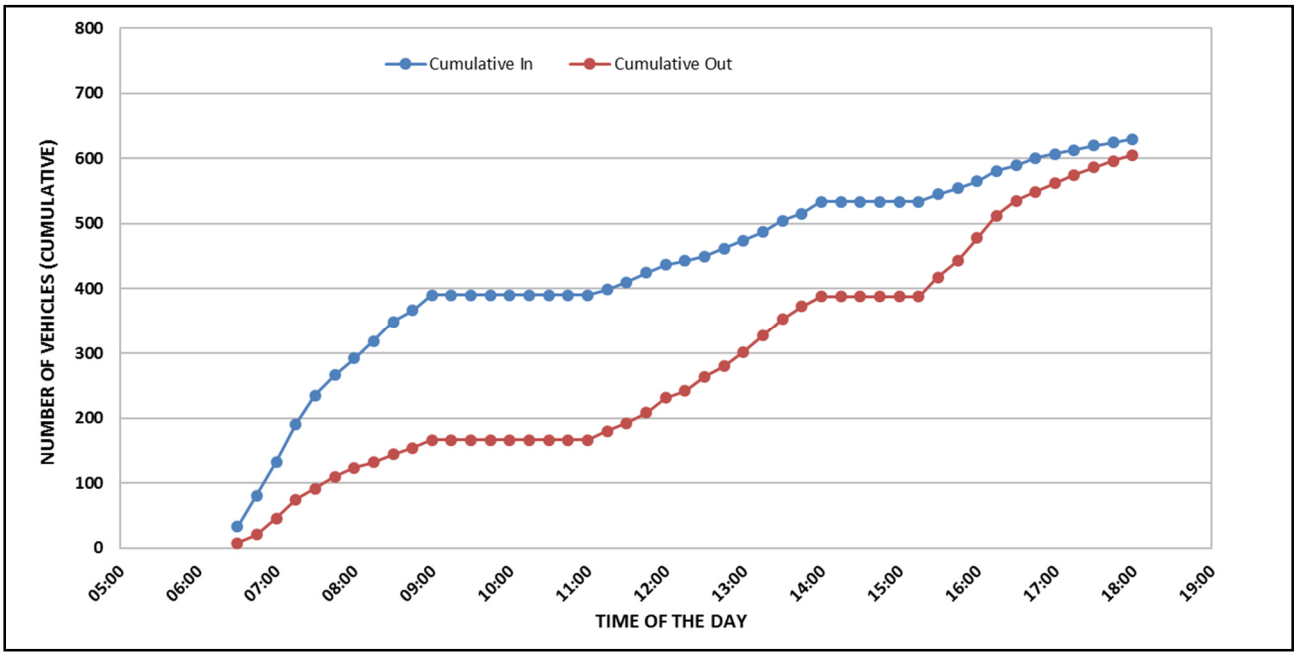


Figure 5-42: Cumulative Traffic Flow Volumes at Edenvale Hospital

5.6.3 Discussions

Table 5-3 shows the parking volume based on the morning peak period traffic survey at private hospitals. The average parking volume varies from 61 to 158 vehicles per hour. The maximum parking accumulation range from 484 to 1 104 vehicles in 3-hour period.

Table 5-7: Parking Volume, Accumulation and Index for Private Hospitals

Hospital (Private)	Parking Bays	Volumes (Veh/hr)		Accumulation (Veh/hr)		Parking Index	
		Max	Avg	Max	Avg	Max	Avg
Private Hospital 1	640	71	61	174	98	0.27	0.15
Private Hospital 2	1700	391	158	1 264	868	0.74	0.51
Private Hospital 3	630	101	86	774	453	1.23	0.72

The parking index shows whether the capacity of existing parking spaces is still able to accommodate the demand for vehicle parking. The parking index is determined by dividing the parking accumulation and parking capacity. The parking index of more than 1 indicates that the parking demand is more than supply.

The parking volume for public hospitals based on the morning peak period traffic survey is shown in **Table 5-8**. The average parking volume varies from 82 to 296 vehicles per hour. The maximum parking accumulation ranges from 657 to 2 070 vehicles over vehicles over the 3-hour period. The average parking index for hospitals is less than 1 which shows the supply is higher than the demand.

Table 5-8: Parking Volume, Accumulation and Index for Public Hospitals

Hospital (Public)	Parking Bays	Volumes (Veh/hr)		Accumulation (Veh/hr)		Parking Index	
		Max	Avg	Max	Avg	Max	Avg
Helen Joseph Hospital	783	387	296	718	466	0,92	0,59
Tambo Memorial Hospital	498	220	165	436	267	0,88	0,54
Edenvale Hospital	264	118	82	224	144	0,85	0,55

5.7 Summary

This chapter reported on the results and discussions of the traffic flows at both private and public hospitals. The results resemble similar traffic flow patterns for the hospital land

use. The chapter discussed the impact of COVID-19 pandemic on hospital traffic flow patterns by comparing the pre COVID-19 data received at some of the private hospitals. Pedestrian volumes were also looked as part of the research.

6. CONCLUSIONS AND RECOMMENDATIONS

The objective of this research was to investigate the impact of COVID-19 pandemic on hospital traffic and the parking demand. The methodology presented in this study also allowed for review of trip generation rates for both private and public hospitals in times of pandemic.

6.1 Key findings

Findings from the literature review:

- The traffic flows in Johannesburg Gauteng drastically reduced even before the forced country Lockdown on the 26 March 2020. The traffic reduction which was measured by level-of-congestion revealed about 10-12% level of congestion as opposed to about 60% level of congestion experienced during the normal weekday periods.

- The traffic flow patterns were highly affected by the imposed lockdowns globally. A study conducted by INRIX for European countries shows that the Vehicle Miles Travelled (VMT) were as low as 7% of pre-COVID data.

- Although no study was found for statistics of COVID-19 impact on the South African hospitals, it can be expected that there was a significant impact on the traffic flow patterns due to the imposed restrictions.

- The hospitals in the United States found-out that there was about 70% change in patient visiting the hospitals and an increase of tele-health. This would mean less traffic flows at hospitals as many patients opted for tele-health consultations.

- A study in Wuhan, China revealed that there was an increase in traffic at local hospitals which could be attributed to the COVID-19 outbreak. This data was gathered for time period prior to the lockdown in Wuhan. The increase in hospital traffic could be as a result of patients flocking to the hospitals when they

experience certain symptoms and because there was no restriction to visiting hospital.

Findings from this Research

Traffic flow

- Hospitals in South Africa experienced lower traffic flow patterns which were due to the lockdown regulations and restrictions to visiting hospitals. The reduction in traffic was found-out by comparing the Google Earth imagery for the time during country lockdown and the time prior the lockdown.

- The traffic flow patterns at the local hospitals remained similar with more inbound traffic during the morning period and more outbound traffic during the afternoon peak period. The traffic volumes during the morning peak period was however 20% higher than the other peak periods. The country lockdown and hospital restrictions resulted in lower traffic volumes compared to the time period before COVID-19 pandemic especially during the midday peak period.

- The peak hour directional split was similar at all the hospitals during all the peak periods. Only the afternoon peak hour at Private Hospital 2 had an opposite directional split ratio.

- The pedestrian trips at private hospitals were mostly employees during the morning and afternoon peak periods. The pedestrian volumes were fewer during the day and these trips are mostly patients visiting the hospital.

  Pedestrian forms a large part of traffic at public hospitals. Most employees and patients at these hospitals make use of the public transport available on the road network surrounding the hospitals. All the public hospitals have made provision for mini-bus taxi holding areas in-front of the hospital properties. The pedestrian volumes at public hospitals were high during the midday compared to the private hospitals.

- The trip generation rates measured during the COVID-19 pandemic at both private and public hospitals were lower that the recommended trip generation rates in the official manuals. The trip generation rates throughout the day were mostly half the rates recommended by COTO (South Africa Committee of Transport Officials, 2012) and SATGR manuals (Stander, H et al., 1995). **Table 6-1** below shows the measured average trip generation rates for both private and public hospitals compared to the recommended trip generation rates from the manuals.

Table 6-1: Trip Generation Rates Comparison

Land Use	*Unit*	*Peak Hour Trip Rate*	
		AM	*PM*
Measured from the Reaserch			
Private Hospitals (Average)	Bed	1,09	0,77
Private Hospitals (Average)		1,45	0,81
South African Trip Generation Rates (Stander, et al., 1995)			
Private Hospital	Bed	1,30	2,10
Provincial Hospital		2,10	2,60
South African Trip Data Manual, TMH 17 (COTO 2012)			
Private Hospital	GLA (100 m^2)	1,65	1,50
Provincial Hospital	Bed	1,50	1,45

Comparing the trip generation rates shows that the measured trip rates were lower than the recommended trip generation rates from the local manuals.

The trip generation rates from data received from private hospital records prior COVID-19 pandemic were lower than the factors in the manuals, however they show more similar rates to the ones measured in July 2020 during the pandemic.

- The parking demand at all the hospitals was far less than the supply due to the safety restrictions implemented by the hospitals. The additional time due to screening process at all the hospital had a negligible impact on the availability of parking at all hospitals.

All the hospitals were using the parking lot for screening. A tent was erected on the parking lot which was used for screening patients and visitors before entering the hospital.

6.2 Conclusions

All the hospitals resemble a similar traffic flow pattern. There was a higher traffic during the morning and less traffic during the midday and afternoon. The trip generation rates at all the hospitals were almost half the trip rates recommended by the local SATGR and TMH16 manuals. Data errors in data collection including traffic counts and hospital parameter factors might have had an influence on the overall results. However, it must be noted that reliable techniques and sources were used to attain data and carry out the analysis.

6.3 Limitations

The following are the limitations to the research method:

- Although counts included pedestrians walking in and out of hospitals, the vehicle counts conducted at hospitals did not include the vehicle occupancy. Therefore, the trip generation rates by person trips could not be investigated.

- The information received from the hospitals did not have some of the variables such as the GLA. Therefore, the trip generation per GLA could not be investigated and compared with the trip generation from the manuals.

- A more in-depth parking investigation could not be conducted for various reasons. One of the reasons was the size of the hospital and number of counters required to capture in-depth parking data.

6.4 Recommendations

The following recommendations are proposed for future research:

- The results from this research should be considered as a base which will be extended in the future. A larger data set should be considered to make valid conclusions on the hospital traffic flows, trip generation and parking demand.

- The vehicle trips in the research can further be classified with vehicle occupancy. This will ensure the capturing of overall person trips from both vehicles and pedestrian counts.

- A 3-day and 13-hour count per hospital will provide more in-depth information on the hospital daily traffic flow patterns. The 3-day results would help better understand the current trip generation indicators for both private and public hospitals. The 13-hour duration will cover the morning and evening changes on working shifts and also the midday traffic.

- A separate research for parking generation at both private and public hospitals should be considered. The study will be a review of parking rates at hospitals and could incorporate the hospital traffic flows.

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Appendix A: Outline for interviews with the hospital representative

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OUTLINE FOR INTERVIEW WITH THE HOSPITAL REPRESENTATIVE

INSTITUTION NAME & ADDRESS: _____

INSTITUTION CONTACT PERSON: _____

INSTITUTION CONTACT NUMBER: _____

INSTITUTION EMAIL ADDRESS: _____

TITLE OF RESEARCH PROJECT: The Impact of COVID-19 on traffic Generation and parking Demand at Hospitals

ETHICS APPLICATION REFERENCE NUMBER: ING-2019-11049

RESEARCHER: Thato Mariti

DEPT NAME & ADDRESS: Department of Civil Engineering, Banhoekweg, Stellenbosch, 7600

CONTACT NUMBER: 082 997 8971

EMAIL ADDRESS: thatomariti@gmail.com

INTERVIEW QUESTIONS

How many employees work at this hospital?

- Doctors,
- nurses,
- assistant nurses,
- general office workers,
- cleaners
- security

How many services are offered at the hospital, list of services?

What is the hospital catchment area?

Does the hospital have nurses training college within the hospital premises?

Does the hospital have nurses accommodation within the hospital premises?

How many shifts does the hospital have?

How many access gates does the hospital have and is there security access control at all the access gates?

CONSENT TO PARTICIPATE IN RESEARCH

I: _____, confirm to be a representative of _[provide hospital name]___. I hereby give permission for _[provide hospital name]___to take part in this research. I acknowledge that this will entail a traffic count by the researcher and providing general information about the hospital by the hospital representative.

RIGHTS OF RESEARCH PARTICIPANTS:

Participants have the right to decline answering any questions and you can exit the survey at any time without giving a reason. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research participant, contact Mrs Maléne Fouché [mfouche@sun.ac.za; 021 808 4622] at the Division for Research Development.

I confirm that I have read and understood the information provided for the current study.	YES	NO
	☐	☐
I agree to take part in this survey.	YES	NO
	☐	☐

Signed: _____

Name: _____

Date: _____

Appendix B: Land Use Characteristics Questionnaire

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LAND USE CHARACTERISTICS QUESTIONNAIRE

No	**Independent Variable**	**Actual**	**Estimated**
1	Hospital Area Size (m^2/ha)		
2	Gross Leasable Area (m^2)		
3	Number of Hospital Beds		
4	Number of services offered by the Hospital		
5	Number of Doctors		
6	Number of Nurses		
7	Number of Assistant Nurses		
8	Number of Cleaners		
9	Number of Parking Spaces		
10	Parking Pricing Management		
11	Working Hours		
12	Number of Working Shifts		
13	Number of Students Trainee		
14	Public Transport Facility		
15	Average number of out-patients served per day		

Employees working Shifts	
First Shift:	Start Time:
	End Time:
Number of Employees	
Second Shift:	Start Time:
	End Time:
Number of Employees	
Third Shift:	Start Time:
	End Time:
Number of Employees	
Parking Cost on Site	
Hours	
Daily	